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THE ROYAL ENGINEERS JOURNAL.

Vol. XIV. No. 1. JULY, 1911.

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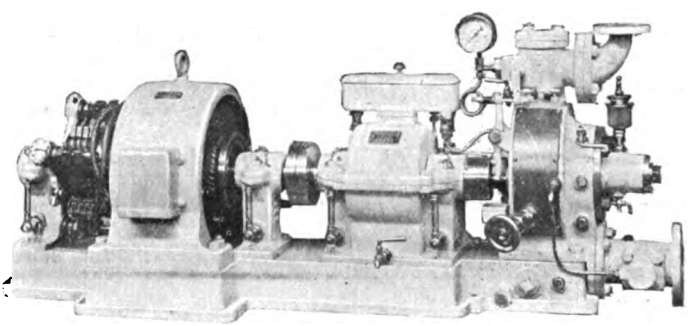

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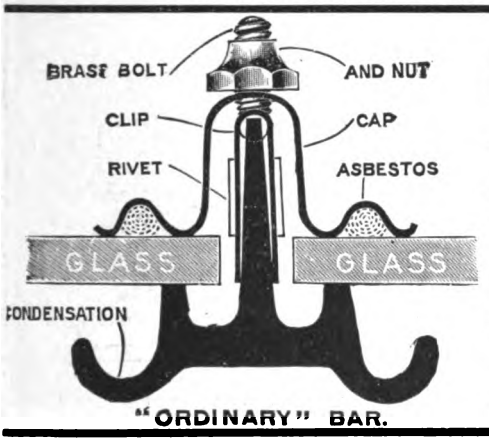

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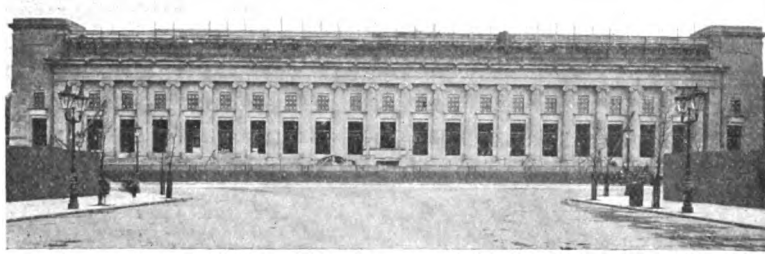

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RAIL TRANSPORTATION OF GIRDERS IN INDIA.

Photo 1.

Photo 2.

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RAIL TRANSPORTATION OF GIRDERS IN INDIA.

By Capt. W. E. Barron, R.E.

The following short account of a nice little bit of work carried out recently in the writer's district, may prove of interest. It consisted of the transportation by rail of four lattice girders, 139′ 6″ overall length and 10′ 6″ depth, for a distance of 80 miles (Phillaur to Umballa Cantonment) on the North Western Railway, at an average speed (including stops for water and to allow a passenger train to pass) of 10 miles per hour. The trip took 8 hours from start to finish.

The maximum speed at any time was about 17¼ miles per hour, when, fearing that the "whip" on such long girders would lash the tail bogies off the rails, we slowed down to a running speed of 15 to 16 miles per hour.

The girders were recovered from the East Beyne Bridge in the Lahore Engineering District, which was having its girders replaced by others of a later and stronger type. They were then specially mounted on bogie frames by the Carriage and Wagon Department of the railway, and were taken to Umballa to form the new road overbridge being erected there in place of a very busy level crossing.

Photo No. 1 is, probably, unique, and represents the four 140′ girders passing over the 100′ girders of the old Sutlej Bridge, just outside Phillaur. The train consisted of an engine, 3rd class composite brake van, composite 1st and 2nd class carriage for the subordinate staff with the train, 1st class reserved carriage for the Assistant District Traffic Superintendent, the writer's carriage, a dummy truck, the four girders, another dummy truck and a brake van, a total length of some 1,000′ odd, more or less.

Photo No. 2 shows more clearly the actual arrangements at the end of the girders, and the staff who travelled with the train, with the exception of the driver and loco. foreman who were busy watering the engine. The staff consisted of (front row) District C. and W. Superintendent, the writer, one of his assistant engineers (seated), Assistant District Traffic Superintendent (with his leg on a tie bar), and back row, Mr. Millett, Bridge Inspector, in personal charge of the train, the guard, and the carriage and wagon inspectors of the Saharanpur and Lahore Districts.

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The total height of the girders from rail level to over rivets was 14′ 1½″. They consequently infringed all our standard running dimensions, and had to be specially sanctioned as a running train by the Senior Government Inspector of Railways, Lahore Circle.

A fuller account of the work will be sent later when it is complete, with other photos, not at present available or taken.

A similar piece of work has never hitherto, the writer believes, been attempted in this country. It was, what is more important, successfully carried through without the slightest interference with the ordinary traffic, over a busy portion of the line of which only 70 odd miles, of the length travelled over, had been recently doubled.

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MEMOIR RELATIVE TO THE SCHOOL OF MILITARY ENGINEERING AND THE CORPS OF ROYAL SAPPERS AND MINERS.

THE following original memoirs by Capt. and Bt. Lieut.-Colonel (afterwards Sir C.) Pasley on the S.M.E. at Chatham, and the Corps of Royal Sappers and Miners, have recently been presented to the R.E. Institute for inclusion in the R.E. Museum. They are of particular interest owing to the celebration of the Centenary of the S.M.E. in 1912.

No. 1.

Account of the Establishment which has lately been instituted for instructing the Corps of Royal Sappers and Miners, and the Junior Officers of Royal Engineers in Military Fieldworks.

The Duty of Engineers in Garrisons is to construct Permanent Works of Fortification, and sometimes Military Buildings.

Their chief duty on actual service, is to throw up the various Fieldworks which may be required for the protection of the Army, when acting on the Defensive and in offensive operations, the management of a Siege comes peculiarly under their charge.

The Stores belonging to the Department consist principally of intrenching and Artificers' tools, to which are added Sandbags and other materials useful in Fieldworks, and Pontoons, etc., for the Passage of Rivers.

The nature of permanent works of Fortification, is so different from that of Fieldworks, and the method of executing them is also so widely different, that the Practical experience acquired by a Young Engineer in any Garrison, is of little or no use to him when he is ordered upon service.

Hence arose the necessity of an Establishment for Exercising

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the Junior Officers of the Corps of Royal Engineers, in the construction of Military Fieldworks.

Upon actual service it often happens, that it may be necessary to throw up lines for the protection of an Army, extending over a great tract of Country, in which case, one Officer of Engineers may often have a District of several Miles allotted to him.

In a Siege the duty of an Engineer is still more arduous. He has large working Parties put under his direction, who are to act within range of the Enemy's Guns, in order to avoid which, the works are marked out and commenced in the dark, which increases greatly the difficulty of making a proper arrangement.

The men who are usually employed in fortifying the position of the Army are either Peasants, or Soldiers of the Line. In a Siege Soldiers of the Line, are always employed under the direction of the Engineers. In respect to these men, the services of some thousands of whom may be required at the same time, the whole of them are totally Ignorant of the nature of the work which they are required to execute, and they must be constantly overlooked and directed even to the minutest Details.

Consequently it is not sufficient that the Officers of Engineers themselves understand their Duty thoroughly. They cannot possibly direct such a great number of Men, without the assistance of a body of N.C. Officers and soldiers, under their own immediate command, who understand the details of all the various operations to such a degree, as to be able to act as Overseers and Foremen of the Working Parties. Hence the necessity of having a well-instructed Corps of Sappers and Miners, that is to say, of men trained to all the various Field duties of the Royal Engineer Department.

In extensive operations it is also almost always necessary to employ a proportion of Officers of the Line as Assistant or acting Engineers. But without well-instructed Sappers and Miners to assist in executing the practical details, such Officers must necessarily be much embarrassed in their new duty; and their Services comparatively speaking, will be of little value; no matter how active or intelligent they may naturally be.

It is an acknowledged truth, that for want of men trained to the duties of Sappers and Miners, the greatest confusion, blunders, and Delays have often taken place in our Sieges, and that many valuable lives have been lost, particularly of Officers of Engineers, who have unavoidably been obliged to expose themselves in a manner that otherwise would have been unnecessary in teaching the working Parties the most simple parts of their duty under the Enemy's fire. One Officer for instance was killed in showing a man how to picket down a Fascine at the first Siege of Badajoz another at Burgos in placing a Gabion. Owing to this Defect a British Army was literally

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incompetent to carry on a regular Siege against a resolute enemy, with any reasonable prospect of Success.

Having made these preliminary remarks as to the necessity of an Establishment for instructing the Corps of Royal Sappers and Miners, and the Junior Officers of Royal Engineers in Military Fieldworks, I shall now proceed to describe the course which has been Adopted.

The men generally commence by cutting a quantity of brushwood which they are taught to manufacture into Fascines, Gabions, hurdles, and Pickets, of the dimensions most useful in Fieldworks.

They are exercised in making Parallels and Approaches such as are used in a Siege.

They afterwards make Batteries of various kinds Elevated, or Sunken, with Fascines and Sandbags.

They are taught to lay Gun and Mortar Platforms.

Also to make Field Powder Magazines.

They are taught the various kinds of Sapping in use, viz. the Flying Sap, the regular Single Sap, and the Double Sap, with the application of them in the formation of Approaches, Parallels, and Batteries, when exposed to Musquet Shot.

They are exercised in Military Mining, in the method of Sinking Shafts, and driving Galleries, and Branches, of the Dimensions most convenient on real service, also in forming the Chamber of a Mine, with the operations of loading, Tamping and Firing.

Every thing is explained, but we have had no explosions except of a few pounds of powder, a sufficient quantity for experiments on a great scale not having been granted.

Our Mines require a considerable quantity of woodwork to support the Earth, but the Frames, etc., are carefully removed and preserved after one set of men has been trained, so that the same timber will serve for many successive Shafts and Galleries.

On the ground at Upnor where our works are chiefly carried on, part of our Parallels, Approaches, and Batteries, are always left to serve as a Model, by which the Officers and Men may see the nature and Progress of the operations of a Siege on a great Scale; the rest of our temporary Fieldworks are destroyed from time to time, and the ground levelled for fresh experiments.

The Fascines and Gabions, after being used in the temporary Fieldworks, are taken to pieces, and delivered over to His Majesty's Victualling Office to serve as firewood for the Public Benefit, so that no part of our brushwood is unprofitably wasted.

The Fieldworks executed are principally those used in a Siege, because there the greatest promptitude, arrangement and expertness are required, and a man who understands Batteries, Approaches,

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and Parallels, will easily comprehend every other kind of Field-work.

In a moral view I conceive this arrangement also to be of great importance. For on a little reflection it may appear evident, that the Recruits on first entering the Corps, must necessarily acquire a bold and enterprising turn of mind, by having their attention constantly occupied with Batteries, Saps, Mines and other works of attack only. And first impressions with young Officers and Soldiers may often decide the character both of individuals and of Corps.

The only thing practised which is not common in a Siege, is the method of using Sods in the revetment of Fieldworks.

From the Practice carried on in the above operations, many improvements have been made in the executive part of the various Field duties of the Royal Engineer Department, and a number of defects or errors have been detected in the rules laid down by the Foreign Authors on Fortification, who formerly were our only guides.

In addition to what has already been detailed, the men are taught the management of Pontoons, and the method of making a Military Bridge of Casks upon a plan much superior to any that is to be found in Books.

The art of constructing Military Bridges in general is likewise explained. In this important branch of knowledge, our Practice has led to decided improvements. By trifling additions or alterations made in the common Pontoon Equipage, which neither increase the expense nor the weight of it to any degree worth noticing, the bridge may be formed in half the time that was before practicable, and its strength has been considerably augmented. The bridge of casks above mentioned has also been reduced to a system ; it is in nowise inferior to the Pontoon Bridge either in strength or safety ; and means have been found for forming and monœuvring it in the most deep and rapid river without the assistance of Boats.

Knotting and Splicing, being useful on many occasions, form a part of the course of Instruction.

After every operation in which they are employed, the men are examined in respect to the nature and use of it, and are also made to give an account of all the technical terms, such as the Interior, Superior and Exterior slopes of a Parapet, etc.

They are likewise exercised in marking out upon the ground Parallels, Approaches and Batteries, and in putting up Profiles to show the form of the supposed work when finished.

The method of levelling ground either horizontally or according to a certain given slope is also taught.

In order to qualify the men for acting as Overseers and Foremen of

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working Parties, they are taught practical Geometry and the Principles of Plan Drawing. This is done on a very economical system. They draw chiefly on slates, only two Plans have hitherto been done on Paper, viz. the Plan and Sections of a Battery, and the Plan Section and Elevation of a small building. This is a branch of Instruction which I consider of the most essential importance, it not only renders the men more useful in the field, but also in Garrisons when employed on the permanent works; for everyone knows that it is of the greatest use to all Artificers to be able to work from Plans and Models.

At Plymouth, the last station where I was quartered, the Civil Artificers of the Royal Engineer Department, owing to their own superior knowledge in this branch of learning, held the Royal Military Artificers in the greatest contempt. This will not be the case in future.

The proportion of men who from their previous education and ability, are qualified for going through the course of Practical Geometry and Plan Drawing, does not on an average exceed one in three, and this is the description of men out of whom the N.C. Officers, and eventually the Sub-Lieutenants of Companies will be chosen. But as it would create great confusion if one part of the men were at work, whilst the others were at study, it has been found expedient, also to endeavour to improve the remainder as much as possible. Those who come entirely uneducated or imperfect are taught to read and write, and others are instructed in Arithmetic. A man of good abilities who arrives totally Ignorant generally learns to read and write before he quits the Establishment. Those who go through the course of Geometry and Plan Drawing, proceed afterwards to the study of Mensuration.

The teachers and assistants are all N.C. Officers or privates. The Practical Geometry and Plan Drawing are taught according to a system composed by me, for this express purpose. The other branches of learning are conducted according to the Reverend Dr. Bell's system, which has lately been introduced into the Army, by the authority of His Royal Highness the Commander-in-Chief.

The men after remaining a certain time at this Establishment are either sent on Service, or drafted to the various Companies in Garrisons. It is my wish that they should never be changed in less than Six Months. The average number of men doing duty here has hitherto been about 250.

The only permanent Officer of Engineers at present attached to this Establishment is an Adjutant, who makes arrangements regarding the executive details of the various duties according to general directions received.

The Officers of Engineers who attend for the purpose of Instruction,

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are charged with the superintendence, and are responsible for the proper execution, of the various operations carried on. They also personally examine the men, or are responsible that it is properly done by qualified N.C. Officers. They make daily and detailed reports of progress, in which they are ordered particularly to mention those N.C. Officers and Privates, who distinguish themselves by their superior Activity, industry, or Intelligence.

The Sub-Lieutenants of the Corps of Royal Sappers and Miners, who are sent here for instruction, also assist in superintending the fieldworks, etc., and make reports of a similar nature to the above, when employed on any duty where an Engineer is not present.

The list of Men recommended by the Officers is read out in public orders once a fortnight, which occasions great zeal and Emulation. I have frequently known the same men recommended every time that these lists were made out, by four or five different Officers.

These recommendations together with general good conduct, and ability shown in the Regimental Schools, are always kept in view, when any opportunity occurs of having N.C. Officers, or Privates promoted to a higher rank.

The Officers of Engineers also assist in all Regimental and Parade duties relating to the discipline of the Men, in the same manner as is Practised in Regiments of the Line. One day in every week besides Sunday evening is set aside for general exercise, in which the usual manœuvres of a Battalion are performed; the men being previously instructed in the Drill, as far as the Manual and Platoon exercises (inclusive) at Woolwich, under the Senior Adjutant of the Corps.

I consider the Drill of great importance not only to the discipline and respectability of the Corps, but also for another reason. Although the men are seldom likely to be called upon to use their arms in the Field; there is no class of Soldiers in whom greater courage is required in order to do justice to their duty. And there can be no doubt but that a confidence in the use of arms adds to the courage of an Individual in all cases and in all situations, because although he may not be actually engaged in personal contest, he feels that if it came to that point, he would be equal to any adversary. If there were not so great a Demand of Men for Service, it would in my opinion be desirable to devote more time to the Drill.

When the Officers of Engineers are not occupied in Military or Field Duties, they have a course of Study laid down for them, calculated to improve them in the Science of Attack, upon which the art of Fortification is founded. They are required to present Memoirs relative to the various operations of a Siege stating the number of Men, Materials and Tools, and the distribution of them, as also

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the time necessary for completing each particular operation on a great scale.

The being able to make such arrangements and the knowledge of these Details, is of the utmost importance to the success of an enterprize, but it is absolutely impossible for any Officer to acquire them from Study or Theory alone. For instance if a Fortress is to be attacked, an Engineer who has been at this Establishment on a hasty Examination of the woods in the neighbourhood, will be able to say whether they will furnish a sufficient quantity of Fascines and Gabions, etc., also what time will be necessary for cutting and manufacturing the brushwood, and how many men and Tools ought to be employed.

It may easily be conceived how little capable of giving any just opinion upon such simple though necessary arrangements, the Officers of Engineers must formerly have been, who were often sent to assist in conducting a Siege, without ever having seen either a Fascine, or a Gabion made or used.

To this want of Practical experience on the part of the Officers themselves, add the total ignorance of the working Parties, whom they were to Direct, and it is difficult to conceive any duty more embarrassing than that of an Engineer upon actual Service. To an Officer who felt deeply for the Credit of his Corps, and the success of His Majesty's Arms, it was a truly distressing Situation.

The above is an ample statement of the nature, and object of the Establishment for Instructing the Corps of Royal Sappers and Miners, of which I have had the honor of being appointed Director.

The allowances granted to the Officers, N.C. Officers, and Privates employed at this Establishment will be seen by referring to His Majesty's Warrant for the formation of it, Dated 23rd April, 1812.

(Sd.) C. W. PASLEY, *Capt., R.E.,*
and Brevet Lieut.-Colonel.

Chatham Lines,
5th August, 1813.

No. 2.

OBSERVATIONS ON THE PRESENT ORGANIZATION OF THE CORPS OF ROYAL SAPPERS AND MINERS.

The Corps of Royal Sappers and Miners is raised for General Service, and by virtue of His Majesty's Warrant must always be commanded by Officers of the Corps of Royal Engineers.

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The Inspector-General of Fortifications, acting under the Master-General of the Ordnance, has the immediate command of both Corps.

The present Establishment of the Royal Sappers and Miners, consists of Four Battalions of eight Companies each.

Every Company is allowed 5 Serjeants, 5 first Corporals, 5 Second Corporals, 70 Privates, and 3 Drummers.

There is only one Commissioned Officer of Sappers and Miners per Company, a Sub-Lieutenant who is always raised from the ranks.

In addition to the above Establishment, each Battalion is allowed an Adjutant and 2 Staff-Serjeants.

The Corps at present is incomplete none of the Companies being filled up, except those which are serving in the Peninsula, and in Canada. For this reason, only two Adjutants as yet have been appointed, both of whom are Second Captains of Engineers.

The Senior Adjutant who is likewise Quartermaster resides at Woolwich, and has the charge of the Recruiting Service of the Corps. He also equips and disciplines the Recruits on their arrival at that place, and the general details and arrangements of the whole Corps, such as posting N.C. Officers and Privates to Companies, etc., are transacted through him.

The duties of the Adjutant at Woolwich have been modelled upon the System followed in the Royal Artillery, where there is an Adjutant to each Battalion.

After the Recruits are drilled a certain number of months at Woolwich under the Senior Adjutant, and are considered perfect in their facings, in marching, and in the Manual and Platoon exercises; they are sent down to Chatham to be instructed in the Field Duties of the Royal Engineer Department, where they are also further advanced in the Drill.

The Recruits enlisted are principally Artificers of various trades, or Miners. A very small proportion of Labourers is also allowed to enter the Corps under certain restrictions. The whole of the Men without distinction of trades are trained as Sappers, Miners, and Pontooneers, and it is my opinion that a sub-division of men of these descriptions into different Corps, as is the case in some foreign armies, would be very prejudicial to His Majesty's Service, inasmuch as it would give rise to a more numerous and expensive Establishment of Officers and Men, particularly of the former, without producing greater efficiency.

It may also be observed, that when the duties of any Military Men such as Engineers, Sappers, Miners, etc., are so intimately connected as to require them always to be done in concert, they should only form one and the same Corps. If they are divided, one Corps must necessarily always be subordinate to another, which will

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injure its discipline and reputation, and its Officers will in a great measure be inefficient, and consequently despised by the rest of the Army.

As a Proof of this I shall give one striking instance in the British Service.

The Officers of the Royal Artillery Drivers, who form a distinct Corps, are always commanded by the youngest Subaltern of the Royal Artillery. In consequence of this circumstance, no young man of spirit or education will willingly enter the Corps of Artillery Drivers, although the Pay and Allowances are much greater than those of the Royal Artillery. On account of their subservient situation, the former class of Officers are not so well received in society, and the men whom they command, although an equally important and useful body of Soldiers, are neither so well disciplined nor respectable as the Gunners of the Royal Artillery.

I consider Artificers upon the whole are the best men for the Corps of Sappers and Miners; particularly Carpenters, Wheelers, and Blacksmiths. An Artificer is generally better educated and more intelligent than a Labourer of the same natural abilities. He is therefore a fitter subject for the Engineer Department, where the N.C. Officers are always required to act as Overseers, and where it is often necessary even to employ Privates as such. As far as regards personal exertion, and the power of enduring fatigue, Artificers in general are not inferior to Labourers.

It was before stated that the Corps of Royal Sappers and Miners is commanded by Officers of the Royal Engineers. It has hitherto been the custom to attach only one Captain of Engineers to each Company, and that generally in a very temporary manner.

This arrangement is certainly not sufficient to ensure the proper discipline of the men upon Service. It is now universally agreed that each Company ought to have its full complement of Officers in the Field, although in garrisons a smaller number may suffice. Sir Richard Fletcher, the Commanding Engineer in the Peninsula, has therefore attached a number of Subalterns of Engineers to each Company, in addition to the Captains, and the same has been done by me at Chatham, but to diffuse the benefits of this System throughout the whole Corps will require a general Order from higher authorities.

One captain and at least two Subalterns of Engineers ought to be permanently attached to each Company, in addition to the Sub-Lieutenant. This will form a very efficient establishment of Regimental Officers. I have reason to believe that Lieut. General Mann has it now in contemplation to carry some measure of this kind into effect.

Like everything new it will not be universally well received at first,

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for many of the Officers of Engineers, from the former habits and custom of the Corps, have a great aversion to all Regimental and Parade duties, which they were taught to consider as a kind of drudgery beneath their Profession. This prejudice has however been gradually wearing away. It is now allowed to be absolutely necessary that a portion of the Officers of Engineers shall do Regimental duty with the men, and nothing which is for the good of His Majesty's Service either is a degradation, or ought to be considered as such.

In the Establishment at Chatham, where all the young Officers are employed in Regimental Duty, no such prejudice exists. On the contrary, a mutual attachment has invariably taken place between the Officers and Men, and they are always anxious to go on Service together.

I need scarcely mention that the present Corps of Sappers and Miners were formerly styled Royal Military Artificers. The Establishment and organization of the Corps remains the same, only that it has been augmented and improved, much more attention having been paid to the discipline of the Recruits, and great care having been taken in their Field Instruction which before was totally neglected, in consequence of which omission they were of little or no use upon service.

Owing to the many defects of the Military Artificers who considered themselves rather as Civilians than as Soldiers, the late change in the title and uniform of the Corps may be considered beneficial, as they must tend to obliterate the memory of the old Artificer. Both the name, Dress and habits of the present men are certainly much more martial and soldierlike. But I must confess although I prefer the title of Sapper and Miner to the former one, for the above reason, yet I still consider the present name unsuited to the Corps.

It appears to me a very great defect that the Officers and Soldiers of any Department should have a different name. Much of the acknowledged indiscipline of the Old Artificers may be ascribed to this cause. The Engineers although constantly doing duty with them, would not allow that they themselves were Artificer Officers, and therefore did not consider their own reputation at all affected either by the good or bad conduct of their men, whom they consequently felt no scruple in totally neglecting.

A very great improvement has no doubt taken place lately in the Military duties of the Royal Engineer Department, and more may be expected, but I conceive that as long as the difference of title remains, the Engineer Officers in general (excepting those who may be attached to Companies for the time being) will still take little interest in the reputation of a Corps styled Sappers and Miners.

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Everything which tends more intimately to unite together any body of Officers and the Men whom they command, must necessarily promote the discipline and efficiency of the whole as a Corps, and any distinction, though but in name, which tends to disunite them, must I conceive be in some degree pernicious. I am therefore persuaded that it would be highly for the benefit of the Service if the title of Sappers and Miners were altogether abolished and if the body of Men so styled were in future considered an integral part of the Corps of Royal Engineers, and known by no other appellation. There would then be no prejudicial distinction between the men and their officers, and each individual, let his rank be what it will, would therefore enter with greater zeal and alacrity, into every duty that could promote the reputation of the whole.

Should this salutary change of name ever take place, I feel confident the British Royal Engineer Department will become in a few years the best organized Military Establishment of its kind in the World.

The Royal Sappers and Miners are always armed in Garrisons. A question has arisen whether it is proper that they should carry Arms in the Field or not. It appears to me of importance that they should.

It may often be necessary upon Service to attach a party of them on a particular duty to a considerable distance from any other Troops. In that case, if they are armed, they may defend themselves, without harassing the rest of the Army. If they are not armed, they must either be protected by a Detachment of Soldiers of the Line, or they are liable to the most serious disasters. It would for instance be a mortifying circumstance, to hear of a detached Company of Sappers and Miners, being surprised and cut to pieces by a few of the enemy's Dragoons or of their being prevented from executing their orders by a dozen armed Peasants. The latter is a thing often likely to occur, even in a friendly country. Such operations as the destruction of a Bridge, the breaking up of Roads, and in short a great number of similar services, in which Detachments of Sappers and Miners are likely to be employed, are always highly offensive to the Natives of the District, whose prosperity they injure, and consequently they cannot possibly be carried into effect by men without arms, in any country which is the Seat of War. As a proof of this, in Sir John Moore's retreat in Galicia, a body of armed Peasants actually assembled in considerable numbers to oppose a British Engineer who was preparing to destroy a Bridge at some distance from the main body of the Army. But when they found that he was determined upon effecting his object, and had drawn up his Party to attack them, if necessary, they desisted from the attempt. It need scarcely be mentioned, that if this Officer and his Men had been

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unarmed, he must have returned without executing his Orders, to the prejudice of the Service.

This case, and many others of a similar nature, which are likely to occur in the course of a Campaign, appear to me to point out the necessity of arming the Corps of Royal Sappers and Miners in the Field, or at least that Arm Chests should always accompany them, ready for distribution when occasion required. I shall not urge as a plea for this measure, the assistance which the men of this Corps might render to the Army in Action, because on every Service there would always be more than sufficient employment for them, in their own peculiar and more important branch of duty, without requiring them to act as Infantry Soldiers. Indeed, one principal advantage of the Corps of Royal Sappers and Miners is, that it will do away the embarrassing necessity which has hitherto constantly occurred on all occasions, both in the Field and Garrisons, of weakening and to a certain degree disorganizing the Regiments of the Line, by taking away their Artificers and Miners, and attaching them to the Royal Engineer Department.

(Sd.) C. W. PASLEY, *Capt., R.E.,*
and Brevet Lieut.-Colonel.

Chatham Lines,
5th August, 1813.

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A FEW NOTES ON THE SIEGE OF DELHI.

By General Sir F. R. Maunsell, K.C.B., Colonel Commandant, R.E.

The perusal of an article in a recent number of the *R.E. Journal* in which the Siege of Delhi was alluded to at some length, prompts the writer, as one of the senior surviving R.E. officers present at that siege, to contribute a few notes which may not only prove of interest but which may also help to bring into prominence some points scarcely alluded to by historians of the Mutiny.

The Siege of Delhi may be divided roughly into three periods; the first, when the original force of some 3,800 men was desperately holding its ground against the daily attacks of the enemy; the second, after the first reinforcements had arrived, with the assurance that in due course sufficient would arrive to allow of assuming the offensive, and during which time also siege material was being collected; and finally the third period when the arrival of the siege train enabled the attack on Delhi itself to be vigorously pushed on until the city was ultimately captured.

This of course precluded any project of the engineer work of the attack which left only details to be worked out on the ground from being prepared in anticipation. Some have asserted that such a plan was prepared by Colonel Baird Smith whilst still at Roorkee, and knowing Delhi, as he did, far better than most men, it is quite possible that he indicated on the Roorkee plan the general site which was afterwards used. But to have done more than this was at the time absolutely impossible, as both the force available and the conditions of a practical project were unknown. The writer can speak with some authority on this point as the plans of all fortified places were kept under his charge at Roorkee, and the plan of Delhi showed no detail of the many buildings, walls, trees and copses which afforded such dense cover on the site ultimately chosen, and a knowledge of such details was absolutely indispensable when considering the scheme of attack. Moreover, the plan itself does not seem to have been taken to Delhi as it was not forthcoming when asked for by the Engineers who were assisting Capt. Taylor later on in thoroughly examining this ground.

Some confusion also has been caused by the unusual position of Colonel Baird Smith. Although nominally Chief Engineer at Delhi, and as such responsible to the General for all schemes for which sanction had to be obtained, his numerous more important staff duties, as well

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as the illness from which he suffered, practically forced him to delegate to Capt. Taylor the actual duties of Chief Engineer, and this the latter virtually became. Luckily Taylor's engineering skill had long been appreciated in Upper India where the Great Trunk Road was known as "Taylor's Road," and in addition to this Lord Lawrence had selected him, on account of his experience at the Siege of Mooltan and his known ability, as the *homme nécessaire* to find the way into Delhi. All this must have been well known to Baird Smith, and have satisfied him that he could safely leave the whole plan of the attack entirely in the hands of his subordinate. It must also have proved a source of great relief to him when he had, in his turn, to back with his authority so daring a project, and to obtain for it the unwilling consent of an over-anxious general weighed down by the responsibilities of so difficult a crisis.

But this unusual relegation of duties has led to some misconception amongst writers, and even General Warrand in his article on Delhi in the January, 1908, number of the *R.E. Journal* says, "To the former (Baird Smith) belongs the credit of evolving the daring plan of attack * * * to Taylor belongs the credit of successfully carrying out the difficult details of Baird Smith's great plan." The writer has the best of reasons for knowing that this is incorrect, and that Taylor not only elaborated the details but also evolved the plan of attack itself.

So many years have now elapsed since the Siege of Delhi, that it is perhaps difficult to realize how great were the dangers and difficulties which had to be overcome before such a plan could be worked out. Although from the very first the capture of the city was the ultimate goal in view, the besieging army for over a month consisted of a small British force holding on like grim death to a fortress of some 6 or 7 miles of rampart, and faced by an enemy vastly superior in numbers and occupying an arsenal and its environments. The only hope lay in the arrival of reinforcements which would enable what was really a defensive position to be turned into an attack. When all possible succour had arrived it was evident that a regular siege with approaches, etc., was out of the question, and that other procedure would have to be adopted. There was little more ammunition than would suffice to form practicable breaches, and if the place were not taken when that was expended the British force would be very much at the mercy of a powerful and resourceful enemy. It was, moreover, evident that a successful attack must be by surprise, and must be carried out with all speed and care so as to save the loss which delay might occasion and which would undoubtedly prove far greater than that suffered in a rapid attack.

There was but one site which allowed of such an attack, and this was covered with buildings, trees, copses, etc., and occupied by the enemy who might at any moment turn it into a strong position. The attack itself was, moreover, a difficult military operation even under

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the most favourable circumstances, and one which required the utmost care and precision. But it was the only way to success, and it was because he foresaw the probability of its having finally to be resorted to, that Taylor, from the first day of his arrival to the time of his taking over the responsibility of all the works, had been examining the ground so as to gauge its adaptability for such an attack. As it was in the hands of the enemy, it was at the constant risk of his life and with many hairbreadth escapes that he carried out this examination, sometimes passing well within their lines and picquets and being nearly a mile away from any succour. The only officer of higher rank who ever accompanied him on his hazardous scoutings was General Nicholson, who threw himself enthusiastically into the work, its very audacity being just what he loved.

We were, of course, more or less aware all along that Taylor was studying the ground. In fact he used some of us (and especially one who was living on the site at the time of the outbreak) to take measurements, etc., at different times. But no one knew what he was actually planning until the stirring week of strenuous and ceaseless action. Nor does the above apply to the Engineers only. The writer is convinced that others in the force had an even less clear conception of what Taylor was doing, and that this accounts for the otherwise inexplicable remarks or assertions made by some historians.

Even after the preliminary reconnaissance had shown how best the buildings and communications might be used, several points had to be kept carefully in view when framing the plan of the attack. In the first place it was of vital importance that, from the time the position was first taken up to the assault, everything should be completed within a limited time of say 10 days.* It was also necessary that, after the lines for men, guns, batteries, etc., had been laid out, the way to get to them should be clearly indicated, so that the parties might be set to work or placed *in situ* during the night, unhampered by having to find their way round buildings, walls and trees, and without arousing the suspicion of the enemy, picqueted close by and on the watch.

Such a task needed an expert of exceptional skill and physical strength, involving as it did many hours of constant labour both by day and night. But it was the *sine quâ non* of a practicable project, and was only complete when the position of the chief breaching battery was marked out within 160 yards of the ramparts.

After the necessary consent of the General had been obtained to the scheme, great care was required so that the position might be taken up with the rapidity and caution which were so essential for the success of the attack. This was only rendered possible by the enemy's blindness in leaving such excellent cover untouched when it might so easily have been rendered almost impregnable, by the

* It actually occupied 7 days from the 8th to the 14th September, 1857.

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ample time that had been available for scouting, by the threatening aspect of the British right, and finally by the supine attitude generally of the force which completely put the enemy off his guard, and which was so suddenly transformed into vigorous action.

Although the successful discovery and choice of the site for the chief breaching battery was really the crown of Taylor's labours, the scantiest reference only is made to it in contemporary documents. Colonel Baird Smith in his report writes that "Capt. Taylor pushing a reconnaissance found a place for the great battery and we adopted it." It has always seemed to the writer that this scarcely does justice to the arduous and dangerous task to which Taylor had been so long devoting himself. More than ordinary precautions were necessary to make quite sure that the troops could seize the positions by night, and rapidly put them in a state of defence so as to hold them against the inevitable counter-attack *next morning*. This of course involved a far more thorough reconnaissance than would have ordinarily been necessary and yet the work finds no recognition in histories of the siege. As regards the site itself of this battery, no praise can be too high for the skill and daring with which it had been chosen. Had it been in any way unsuitable, it would have given the enemy time and opportunity for a sortie in great force and the whole plan must have failed. Had it failed, the fate of the Delhi field force would practically have been sealed, as many a long day must have passed before any succour could have arrived, and, in fact, it was over six months after the fall of Delhi that the force from England was strong enough to capture Lucknow.

It was therefore this battery that practically opened the door to Delhi and, although the greatest credit is due to those whose reckless courage put the seal on the great work, still greater praise is due to the man who, with equal courage, forged the key by which the door was opened. It was for this reason that Sir George Chesney—our Brigade-Major at Delhi and, as such, one well able to apportion the work done—said, when introducing Sir Alexander Taylor at Cooper's Hill College, "This is the man who took Delhi, thereby saving the British Empire in Northern India." Doubtless those who wrote or reported on the glorious issue had no clear conception of the desperate nature of this preliminary work and therefore scarcely referred to it.

Although Taylor had thus by dogged pluck and unremitting labour pieced together his splendid scheme of attack, he was more than fortunate in having in Baird Smith a chief who was not only able to grasp the practicability of so daring a project, but who was, by his great influence and personality, able to convince General Wilson. The latter, being a distinguished Artillery officer, was well aware of the terrible strain that the siege would throw upon the artillery and engineer working parties, and was in consequence more keenly alive to

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the risk of such a scheme and to the almost insuperable difficulties it seemed to offer. But his able staff (one of whom was subsequently nominated Viceroy of India) all agreed that the chance of success lay in its adoption, and this finally determined him to give his approval. The greatest responsibility, however, devolved upon Colonel Baird Smith, of course, and all honour is due to him, for had he not boldly faced and overcome all opposition the assault and fall of Delhi might have been deferred with disastrous results.

The fame and services of Colonel Baird Smith stand on a higher platform—to use the words of General Taylor—than that of the military engineering scheme on which the fame of the latter rests. His work was of the highest importance, touching such matters as policy, the maintenance of the British power at the time and later on, correspondence with the Government, etc., and the endless considerations and decisions necessary both to carry on the siege, and also in connection with the reinforcements that might be expected. Such duties were all important and enabled him to play the part of a trustworthy and able counsellor to an anxious and harassed General who, leaning very much upon him, efficiently filled for months, and finally carried to a glorious issue, a command and a responsibility so great that three generals in command before him had succumbed in a few days in succession.

Although in virtual charge of all defensive work on the right of our position on the Ridge from the day that it was first occupied, the writer had but little communication with Colonel Baird Smith, and this was early in the siege and in connection with some arrangements at Roorkee. A day or two before the assault, also, he received a note from the C.E.'s quarters in camp saying "all goes well with you." Appointed Director of the Right Attack upon Delhi, under the direct instructions of Capt. Taylor, he traced on the 7th–8th September, under the latter's directions and after he had chosen the site, the first battery whose guns were to crush the Mori Bastion and to deprive it of its command over the left or main attack. The guns on its left flank commanded the ground between the Kashmir Gate and our main attack, and without them the construction of the breaching batteries would have been impossible. As it was the work was hazardous in the extreme. Another object of battery No. 1 was to lead the enemy to suppose that the attack would be developed on the right flank. In this it was entirely successful, and desperate were the efforts the mutineers made to crush the attack on the right. This battery was thus, as intended by Capt. Taylor, a key to the whole attack.

In connection with the above notes a few words may not be out of place regarding General Nicholson. He was the embodiment of what one might look for in a great soldier and man, whose aspect, somewhat reserved though impetuous, spoke of command and success and inspired an abiding respect and confidence. It is said that a warlike

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tribe started a religion of which he was the quasi-deity. He was the best known of those officers charged by Lord Lawrence with the disarmament of all the regiments in the Punjab. He also pursued and destroyed one large body of rebels which had revolted and started for Delhi. Later on he led a force from Delhi against a strong body of mutineers which was moving to attack or capture the siege guns *en route*. He captured, instead, all their guns and drove away the remnant. He at once grasped and cordially seconded Taylor's work, associating himself with him both by day and night, running the same hairbreadth risks, and fully comprehending and entering into the whole scope of the scheme. No one else had the same personal knowledge of the exact project, and it was the very audacity in placing the great breaching battery within almost a stone throw of the rampart that charmed him. His frequent passing between the siege site and headquarters was to expedite the requirements of men and material.

Nicholson's death was a very great loss. He had always hoped ardently for a command in the field for which he was so eminently fitted, but little scope for such a command could exist until Delhi fell. Even when dying he did not forget the man with whom he had been so closely associated throughout the siege, and his words "Taylor took Delhi" and "if I live the world shall know it" show how fully he appreciated the value of the work in which he himself had taken so exceptional a part. Possibly, also, he realized that he alone could ensure its recognition, as he knew that no other officer of higher rank had witnessed it, and that Taylor was the last man to speak of it as reflecting any credit upon himself.

Although the Engineering aspect has been principally dealt with in these notes, the actual work done by the Engineers in marking out the ground was simple enough and of no particular interest. The real interest of the Siege of Delhi centres in the heroic and hazardous way in which the scheme of attack was slowly pieced together, and in the gallantry—equally displayed by all—which enabled a much-tried General to utilize to the fullest extent the inadequate means at his disposal, and a handful of British soldiers to crown with success a desperate undertaking which saved not only the lives of thousands of their fellow countrymen, but the future existence itself of the British Empire in India.

In conclusion, it seems to be a curious fact that the most striking feature of the Siege of Delhi has never been noticed. It is surely unprecedented in warfare that, not only in the face of but also almost in the midst of a watchful enemy, what was obviously the site for the final struggle was completely surveyed, and the position of every gun, of the attacking force itself, and of all the approaches were clearly marked out on the ground, and the action finally carried out exactly as originally planned.

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ROLL OF THE CORPS.

By CAPT. H. BIDDULPH, R.E.

IN the list of R.E. officers published by the R.E. Institute in 1898 the two following names appear :—

437.	Elliott, Theodore Henry...	2nd Lieut. 7. 5. 10. Lieut. 1. 5. 11. 2nd Capt. 18. 11. 20.	Peninsula. 1811–13.	Permt. h.p. 19. 10. 26. d. in London. 2. 4. 42.
523.	Elliot, Francis Edward ...	2nd Lieut. 1. 8. 14. Lieut. 1. 7. 15.	—	Retd. (joined the line) 8.2.26.

As both these officers had the distinction, (probably unique for Royal Engineers) of serving in India between 1815 and 1820, the following additional information may be of interest :—

The E.I. Register for 1815 (2nd edition) shows that Lieut. T. H. Elliot, R.E., went to India in the capacity of Military Secretary and Aide-de-Camp to the Rt. Honble. Hugh Elliot, Governor of Madras. The Registers for 1816, 1817, and 1818, have the same entries.

The Register for 1819 shows Lieut. F. E. Elliot, R.E., as private secretary, military secretary and aide-de-camp to the Rt. Hon. Hugh Elliot. The Register for 1820 (1st edition) shows Lieut. T. H. Elliot, R.E., as Military Secretary and Aide-de-Camp, and Lieut. *E. F.* Elliot, R.E., as private secretary. The Rt. Honble. Hugh Elliot vacated office in that year and no further information is available therefore from the E.I. Registers.

If however we turn to the Military despatches of the Pindarry and 2nd Mahratta War (1817–19) we find that Lieut. T. H. Elliott, R.E., took the field as 2nd Aide-de-camp to H.E. Lieut.-General Sir T. Hislop, Bart. (C.-in-C. Madras), C.-in-C. of the Army of the Dekkan, and in this capacity was present at the Battle of Maheidpore, 21st December, 1817, and at the attack and capture of Fort Talneir, 27th February, 1818. The following are extracts from Sir T. Hislop's despatches :—

(1). "Camp on the Soopra, opposite Maheidpore, 23rd December, 1817.

* * * * *

Wounded.

* * * * *

C.-in-C.'s personal Staff. Lieut. Elliott, Aide-de-Camp, slightly."

* * * * *

(2). "G.O. by the C.-in-C. dated Headquarters of the Army of the Dekkan, Camp at Talneir, 28th February, 1818.

* * * * *

The C.-in-C. had on this arduous occasion to deem himself most fortunate in experiencing the able, zealous and valuable services of his Aide-

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de-Camp, Lieut. Elliott of the Royal Engineers, of which in consequence of the Wounds he received early in the battle of the 21st December last, H.E. had to lament the privation during the remainder of the day. * * * "

In Lake's "Sieges of the Madras Army, 1817–19," among the names of the Engineer officers present at the attack on Talneir is included that of "Lieut. T. H. Elliott, Royal Engineers, doing duty."

It is also possible that this Lieut. T. H. Elliott, R.E., was present at the famous Battle of Seetabuldee, 26th—27th November, 1817, for in the autobiography of Lieut.-General Sir J. B. Hearsey (who as adjutant of the 6th Bengal Cavalry was present and took part in the desperate cavalry charge which helped to turn the fortunes of the day) the following occurs in his account of that battle :—

"There were four of us officers present, viz.: Capt. Elliott (this officer was an A.D.C. to Sir J. Malcolm and had been left at Nagpoor sick when Sir John had passed the Residency there on his way to Indore), Lieut. Clark, 24th Madras N.I., Dr. Niven of the same corps and myself. We were standing opposite to each other talking when the very first cannon shot from the small hill struck off the heads of Clark and Niven, splashing Elliott and myself with their brains. I told Elliott that we had better step back one or two paces to get out of the immediate line of fire."

Sir J. Malcolm was an officer of the Madras Army, and served as a Brigadier-General commanding the 3rd Division and Political Agent to the Governor-General during the War. No other officer of the name of Elliott (or Elliot) appears in the Madras or Bombay Army Lists of 1817, and though there is one Lieut. Elliott of the Bengal Native Infantry, he is shown as doing duty with the Bengal Pioneers and is not likely to have been an A.D.C. to a Madras officer. Sir J. Malcolm was present at the Battle of Maheidpore ; and it is possible that Sir J. B. Hearsey writing after the lapse of some 40 years thought that Elliott was Malcolm's Aide-de-Camp instead of Hislop's.

On 19. 10. 26 Capt. T. H. Elliott was placed on the permanent h.p. list of the *Royal Engineers ;* on 20. 3. 27 he was promoted Major *unattached, British h.p.*, and given the rank of Lieut.-Colonel in the Army on 23. 11. 41.

Lieut. F. E. Elliot was placed on the h.p. list of the *Royal Engineers* 1. 4. 17, restored as Lieutenant, R.E., 12. 1. 25, promoted Captain *unattached, British h.p.* 10. 6. 26, exchanged with John Tobin as Captain into the 11th Foot on 28th August, 1846, and sold his Captaincy the same day to Lieut. Jas. Howard Fetherston (*vide London Gazette*). Finally it is to be noted that these officers have their names spelt as Elliott or Elliot indiscriminately, and that from about 1820 onwards F. E. Elliot's name is given in the Army Lists as E. F. Elliot.

Perhaps some readers of the *R.E.J.* can give further particulars as to the Indian Services of these Officers, and of their relationship to each other and to the Rt. Honble. Hugh Elliot.

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THE PHOTOMETRY OF SEARCHLIGHTS.

By Capt. A. D. St. G. Bremner, R.E.

As there is very little in the Electric Light Manual on the above subject, the following may perhaps be of interest and use, presuming a knowledge of Volume II. of the Manual :—

The Science of Illumination has been based upon an arbitrary and utilitarian system of units, derived from the light-giving powers of certain standard light sources.

Luminous Intensity (I) admits of the most ready and accurate measurement of all the photometric quantities, and its units form the basis of definition of the remaining units of the system.

Since 1st April, 1909, the following simple photometric relations have been accepted :—

1 International candle = 1 Pentane candle (British Harcourt lamp).
" " = 1 Bougie decimale (French candle).
" " = ·104 Carcel (French colza-oil lamp).
" " = 1·11 Hefner unit (German amyl-acetate lamp).
·90 International candle = 1 Hefner unit.

Luminous Flux (ϕ) denotes quantity of light, and its unit is the Lumen, which emits unit I within unit solid angle.

Unit solid angle is the angular space subtended at the centre of a sphere by an area of its surface equal to the square of its radius.

The total angular space about a point = 4π or 12·5664 solid angle units.

The value of the Lumen used here is that derived from the International candle.

The light of a source whose average intensity in all directions is 1 candle-power (c.p.) = 1 mean spherical c.p. or 1 spherical candle. This term is commonly used as a measure of mean luminous intensity, but it obviously refers to a definite quantity of light flux with a value of 12·5664 lumens.

Illumination (E) denotes the density of the light flux falling on a surface, and its unit is the candle-foot = 1 lumen per square foot, or the illumination received by a surface at every point 1′ distant from a source of 1 c.p.

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An illumination of 1 lumen per square metre = 1 lux or metre-candle, and is most commonly used on the Continent.

1 Candle-foot (Cd.-ft.) = 10·75 Luces, using International candles.
= 11·94 Luces, using Hefner units.

The Intrinsic Brilliancy (*i*) of light sources may be expressed as the lumens emitted per sq. ft. of radiating surface, or more commonly the c.p. per sq. in. of surface exposed in a given direction.

Mutual Relations of Photometric Concepts and Units.

Concept.	Symbol.	Unit.	Defining Relation.
Intensity	I	Candle-power ...	$I = \frac{d\phi}{d\omega}$
Quantity	ϕ	Lumen	$\phi = I\omega = 4\pi I_{ms}$
Quantity / Mean Intensity ...	I_{ms}	Spherical candle...	$I_{ms} = \frac{\phi}{4\pi}$
Illumination ...	E	Candle-foot ...	$E = \frac{\phi}{A}$. $E = \frac{I \cos\theta}{l^2}$
Brilliancy	*i*		$i = \frac{I}{a}$

Note.—ω = solid angle units. A = area illuminated (sq. ft.). a = apparent area of source (sq. in.).

If a small screen of area A is placed normally to the rays coming from a source of light of intensity I at a distance *l*, the quantity of light falling on the screen will be, by the law of inverse squares :—

$$\phi = \frac{IA}{l^2}$$

$\frac{A}{l^2}$ is a measure of the solid angle subtended at the source.

ϕ given out in a small solid angle ω can therefore be expressed as $\phi = I\omega$

If I is the same in all directions, the total ϕ emitted by the source $= \frac{4\pi l^2 I}{l^2} = 4\pi I$

The illumination E at any point is the ratio of the quantity of light falling on a small area surrounding the point and normal to the rays, to the magnitude of that area :—

$$\therefore E = \frac{\phi}{A}, \text{ but } \phi = \frac{IA}{l^2}$$

$$\therefore E = \frac{I}{l^2}$$

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If the rays are at an angle of incidence θ with the normal to the surface, then from the law of cosines :—

$$E = \frac{I \cos \theta}{l^2}$$

M. Violle has shown that the intrinsic brilliancy (i) of the crater of a carbon arc remains sensibly constant, being limited by the temperature of volatilization (3,500°—4,000° C.).

If the "i" of a fully developed arc is about 190* c.p. per sq. m.m. of crater area, the intensity of an arc (150 amps.—60 volts, crater diam. =2·5 c.m.) will be about 100,000 c.p.

Reflection.

The ratio of light reflected by any surface to that incident upon it is known as its coefficient of reflection. This coefficient has a value dependent upon the physical character of the surface and when its reflecting power is selective, upon the colour composition of the incident light. Thus a surface of high reflecting power for red might show a high reflection coefficient under the light of the carbon filament lamp and practically zero reflection coefficient under the green light of the mercury arc. Coefficients of reflection are best stated in terms of daylight, and special determinations or a due allowance should be made when dealing with light of any other colour.

The following table gives approximate results collected by Bell :—

Material.	Co-efficient.	Material.	Co-efficient.
Highly polished silver ...	·92	Light pink paper	·36
Mirrors silvered on surface	·7—·85	Yellow cardboard ...	·30
Highly polished brass ...	·7—·75	Light blue cardboard ...	·25
Highly polished copper ...	·6—·7	Brown cardboard ...	·20
Highly polished steel ...	·6	Plain deal (dirty)	·20
Polished gold	·5—·55	Yellow painted wall (dirty)	·20
Burnished copper... ...	·4—·5	Emerald green paper ...	·18
White blotting paper ...	·82	Dark brown paper ...	·13
White cartridge paper ...	·8	Vermilion paper	·12
Ordinary foolscap... ...	·7	Blue-green paper ...	·12
Chrome yellow paper ...	·62	Cobalt blue	·12
Orange paper	·5	Deep chocolate paper ...	·04
Plain deal (clean)... ...	·4—·5	Black cloth	·012
Yellow wall paper ...	·4	Black velvet	·004
Yellow painted wall (clean)	·40		

* 130 c.p. according to Ives and Luckiesh, 1911.
250 c.p. is considered possible in America.

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COLOUR COMPOSITIONS.

The following table gives values for the primary colour elements determined by Ives :—

Source.	Red %.	Green %.	Blue %.
Average daylight	100	100	100
Blue sky	100	106	120
Overcast sky	100	92	85
Afternoon sunlight	100	91	56
Direct current carbon arc	100	64	39
Mercury arc	100 (?)	130	190
Tungsten lamp	100	55	12·1
Tantalum lamp	100	49	8·3
Carbon lamp	100	45	7·4
Flame arc	100	36·5	9
Gas flame, open fish tail burner ...	100	40	5·8
Hefner lamp	100	35	3·8

MIRRORS.

Glass is an excellent material for mirrors, as it is capable of taking a high polish, and when silvered possesses excellent reflecting properties ; for a long time, however, all efforts to manufacture parabolic mirrors of sufficient accuracy from glass were unsuccessful.

The mirrors had therefore to be made with a spherical surface. This necessitated the use of small effective angles ; for as soon as the ratio of mirror diameter to focal length exceeded a certain value, the deviation of the reflected light from parallelism became so great that no advantage could be gained by increasing the effective angle.

A great advance was made by Mangin, in 1876, who eliminated spherical aberration almost entirely, by giving the glass the form of a concavo-convex lens, instead of making it of uniform thickness, as long as the mirror diameter was not greater than its focal length.

On the other hand, the effective angle was only about 60° on account of the comparatively great focal length, and the mirror therefore reflected only a small part of the light emitted from the source.

In 1886, however, Schuckert, at Nuremburg, succeeded in manufacturing true parabolic glass mirrors by a method patented by him and Munker.

The disadvantage of the great liability of glass mirrors to crack (especially Mangin type) has led to many experiments with metallic mirrors, but so far little success has been obtained. A gold plated metallic mirror shows the most promising results, but it is not so

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good in clear weather and has not the same dazzling effect as silvered glass patterns.

Parabolic Mirrors.—It is found that the light of the full moon will illuminate a torpedo boat at about 1,000^{x} range sufficiently for effective gun fire. The E of the full moon at the earth's surface=·01358 candle-feet. It varies between ·0166 cd.-ft. and ·01 cd.-ft.

In order to produce this E at 1,000^{x}, the I of the source of light must be 122,220 c.p. The sunlight in London varies between 30 and 40 cd.-ft.

The most powerful source of light at present available is an electric arc taking about 150 amps., and the curve of its light distribution is shown in *Fig.* 1. The line of greatest intensity makes an angle of about 45° with the axis of the carbons.

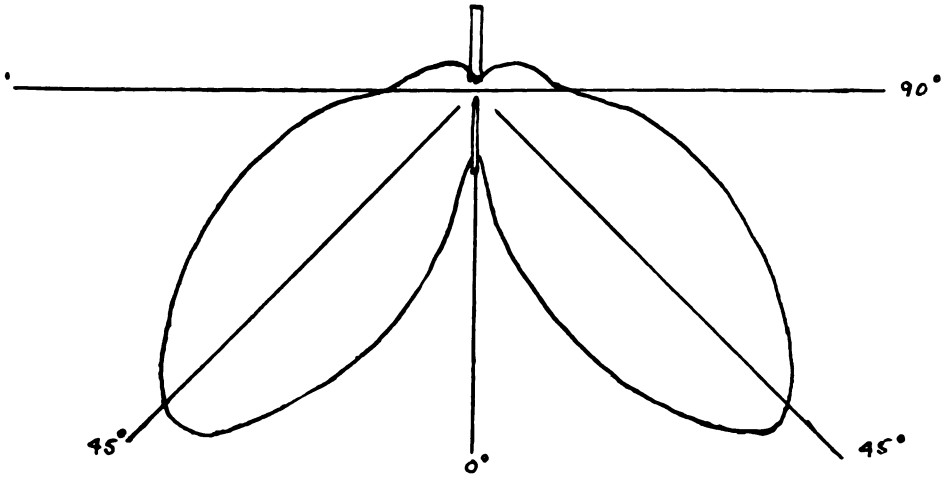

Fig 1.

The solid angle subtended at the arc by the edge of a mirror is called the effective angle of the mirror.

If a point source of light is placed at the focus of a true parabolic mirror, all the rays falling on the mirror will be reflected parallel to the axis.

In *Fig.* 2, let BAH and BDH be paraboloid and spherical mirrors respectively, with F as the focus and centre respectively.

The effective angle of both = $\angle$ BFH = ω.

If a point source of light of intensity I is placed at F, the ϕ on the spherical surface = $\frac{IA}{l^2}$, where l = radius of sphere.

$$= \frac{I}{l^2} 2\pi l \times l \left(1 - \cos \frac{\omega}{2}\right)$$

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but $1-\cos\frac{\omega}{2}=2\sin^2\frac{\omega}{4}$

$\therefore\phi=I4\pi\sin^2\frac{\omega}{4}$

$4\pi\sin^2\frac{\omega}{4}$ is a measure of the solid angle subtended at the source.

The paraboloid receives the same quantity of light.

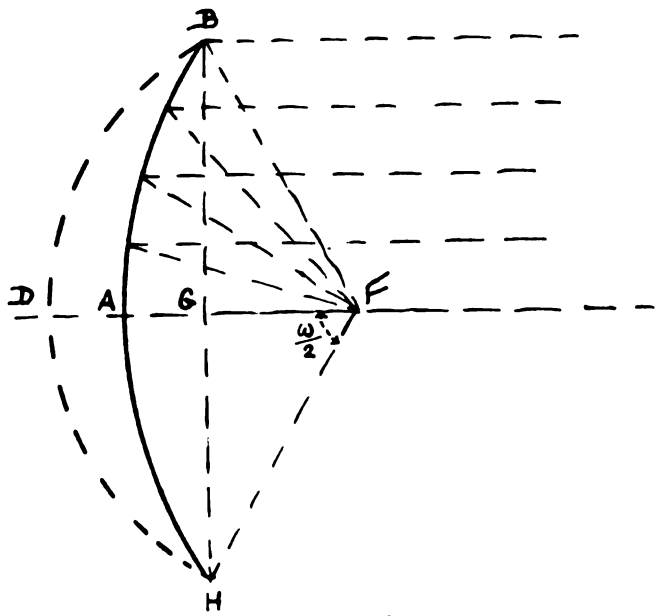

Fig 2.

If the source of light is a circular disc of diameter $d=ac$ (*Fig.* 3), and the focal length$=f$, rays coming from the centre F will be reflected parallel to the axis, and those coming from other parts of the source will be reflected with a certain deviation from parallelism which is greater, the greater the distance from F. Thus, a ray coming from a to the vertex will be reflected to c, and thus the angle aAc gives the conical angle of the reflected beam.

This angle is β where $\tan\frac{\beta}{2}=\frac{d}{2f}$

At a great distance R from the mirror, a surface will be illuminated having a diameter $P=\frac{Rd}{f}$

This surface will be illuminated (supposing perfect reflection from mirror) by original ϕ of light$=I4\pi\sin^2\frac{\omega}{4}$

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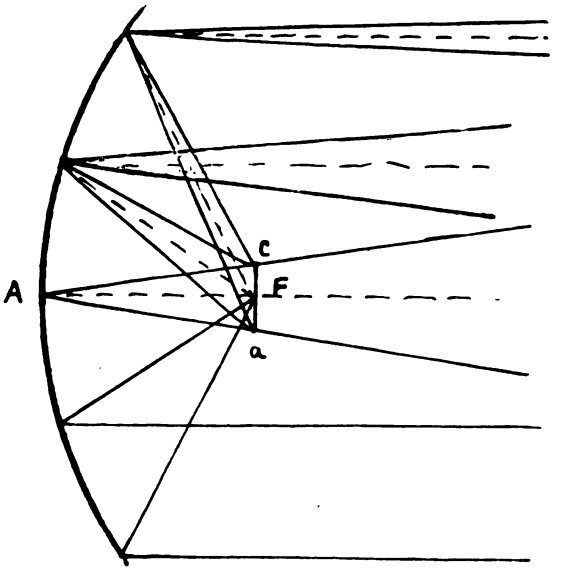

Fig 3.

If beam were parallel, ϕ at R would be distributed over area $=\frac{\pi D^2}{4}$, where D=diameter of mirror, but as light is distributed over a larger area, the candle-feet will be less by ratio $\frac{D^2}{P^2}$

If no mirrors were used and the surface P were illuminated by the same source of light emitting rays equally in every direction,

$$\therefore \phi = I_4 \pi \sin^2 \frac{\beta}{4}$$

$$\therefore \frac{\phi \text{ with mirror}}{\phi \text{ without mirror}} = \frac{I_4 \pi \sin^2 \frac{\omega}{4}}{I_4 \pi \sin^2 \frac{\beta}{4}} = \frac{\sin^2 \frac{\omega}{4}}{\sin^2 \frac{\beta}{4}},$$

which gives a measure of the increased effect, *i.e.*, the intensification (I_1) of the mirror.

In practice, the relation is slightly different, since only that part of the light falling on the vertex of the mirror is reflected at $\angle \beta$, while for every other part of the surface the dispersion is smaller.

In practice, we can with sufficient accuracy write $\frac{\sin^2 \frac{\omega}{4}}{\sin^2 \frac{\beta}{4}} = \frac{D^2}{d^2}$

$$\therefore I_1 = \frac{D^2}{d^2}$$

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The obscuration caused by the negative carbon was at first minimized by having the carbons at 20°—30° with the vertical, thus giving a greater I in one direction, but this plan is suitable only with mirrors of small effective angle.

Horizontal carbons are now most generally used and possess advantages even for mirrors with effective angle of 83°, as the light from the $-^{ve}$ carbon is reflected from the $+^{ve}$ crater and increases the total ϕ from the latter.

If I_m is the mean intensity of that part of the light falling on the mirror, the amount of light reflected (neglecting all losses)

$$=\phi=I_m 4\pi \sin^2\frac{\omega}{4}$$

If this were uniformly distributed over a cone of vertical angle β, a surface of diameter P and area $4\pi R^2 \sin^2\frac{\beta}{4}$ would be obtained at distance R and the illumination of the surface would be :—

$$E=\frac{I_m 4\pi \sin^2\frac{\omega}{4}}{R^2 4\pi \sin^2\frac{\beta}{4}}=\frac{I_m \sin^2\frac{\omega}{4}}{R^2 \sin^2\frac{\beta}{4}}$$

Since the ϕ on the surface $=\phi$ on the mirror, the intensity at the surface $=I_R=I_m\frac{D^2}{d^2}$

But the beam is not uniform, being greatest at the centre and falling off rapidly at the edge. The greatest difference in brightness occurs when the mirror is truly parabolic, but the manufacturer can introduce definite alterations in the form of the mirror, tending to make E uniform. An increase of the central illumination up to 35 % above the mean intensity of the beam is advantageous.

The determining factors for the distribution of intensity and for the intensity of the beam as a whole, is the intensification, *i.e.*, the correct choice of the effective angle and the angle of the beam.

As upper limits, take 140° for the effective angle and 3° for the angle of dispersion. These figures for the service 90 c.m. projector are 112° 44′ and 2° 44′ respectively.

Now I_m and $\sin^2\frac{\beta}{4}$ are both proportional to area of crater, but area of crater increases in proportion to the electrical energy without great increase in intrinsic brilliancy, so that the ratio $\frac{I_m}{\sin^2\frac{\beta}{4}}$ remains about the same with increasing current strength. With a larger quantity of light there is therefore no appreciable gain in penetrating power.

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If the I in the zone of greatest illumination is divided by the watts and the result plotted as in *Fig.* 4 against the watts, for small lamps using a small number of watts, a considerable increase in "i" of the crater takes place with increasing current but the area of crater does not increase in the same proportion as the total ϕ.

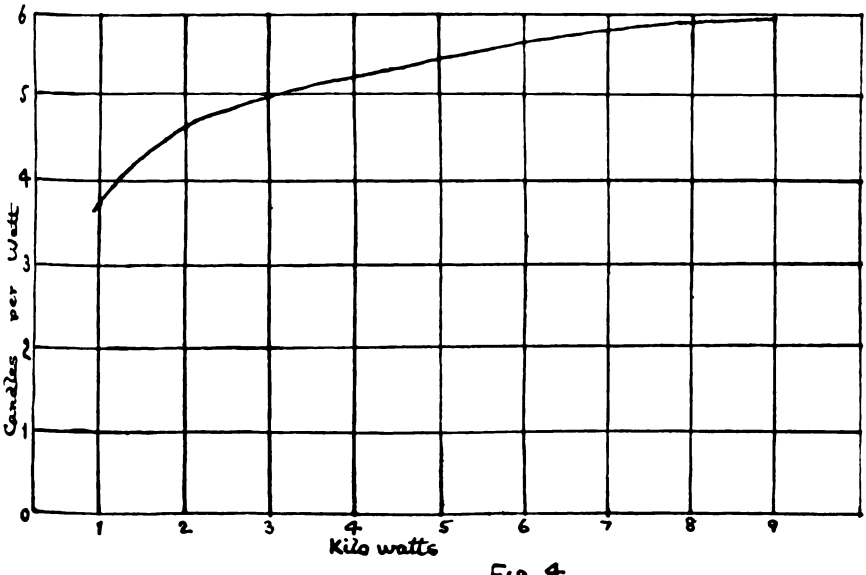

Fig 4

But at higher currents, the increase in "i" is very small and there is greater irregularity in the form of the crater, so that practically there is no increase in penetrating power obtainable by increasing the current beyond a certain value.

SEARCHLIGHTS.

The intensity of a searchlight is defined as the ratio of the total quantity of light reflected from the mirror to the solid angle of the cone of light.

The total quantity of light reflected (assuming no loss on reflection) is $\phi = \frac{\pi}{4} i d^2$

The solid angle subtended by the source at the centre of the mirror $= 4\pi \sin^2 \frac{\beta}{4}$

$$\therefore \text{the intensity } I_s = \frac{i d^2}{16 \sin^2 \frac{\beta}{4}}$$

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Since β is a small angle we can put

$$\sin\frac{\beta}{4}=\tfrac{1}{2}\sin\frac{\beta}{2}=\tfrac{1}{2}\tan\frac{\beta}{2}=\tfrac{1}{2}\left(\frac{d}{2f}\right)$$

$$\therefore \sin^2\frac{\beta}{4}=\tfrac{1}{16}\left(\frac{d}{f}\right)^2$$

$$\therefore I_s=if^2$$

But for different sizes of mirrors the ratio of diameter to focal length is approximately constant,

$\therefore I_s=CiD^2$, where C is a constant.

Let O=observing distance, *i.e.*, distance from observer to target, and L=distance of illumination, *i.e.*, distance from light to target.

When the maximum "O" for a given "L" and size of searchlight has been determined, the value for other sizes can be calculated. As mirrors of 90 c.m. diameter are now in general use, this size may be taken as the standard. In order to obtain a maximum "O" with a given "L," a definite intensity of illumination is required for the given target, and equals $E=\frac{CiD^2}{L^2}$

In order to see the target at the same "O" equally well with another searchlight S_1 we must have $\frac{Ci_1D_1^2}{L_1^2}=\frac{CiD^2}{L^2}$

$$\therefore L_1=\sqrt{\frac{i_1D_1^2L^2}{iD^2}}=L\frac{D_1}{D}\sqrt{\frac{i_1}{i}}$$

If O=L, call this the radius of action=R.

The brightness of the image of the target formed on the retina of the observer's eye will be directly proportional to the illumination of the target and inversely proportional to the square of the distance, *i.e.*, to $\frac{E}{R^2}$. Substituting for E as above, we have the brightness proportional to $\frac{CiD^2}{R^4}$.

To obtain an equally bright image of the same target with another searchlight S_1 we must have the brightness proportional to $\frac{Ci_1D_1^2}{R_1^4}$,

$$\therefore R_1=\sqrt[4]{\frac{R^4i_1D_1^2}{iD^2}}=R\sqrt{\frac{D_1}{D}}\sqrt[4]{\frac{i_1}{i}}$$

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If the beam is spread out horizontally by dispersing lens, the E of the target will decrease by the ratio of the angle β of beam when concentrated to angle λ when dispersed.

In addition, the mean horizontal intensity is to be considered and not the axial intensity of the beam, as with a concentrated beam. The mean horizontal I = 65 % of the axial I approx.

The radius of action R_s with dispersed beam can therefore be obtained by the formula

$$R_s^4 = \frac{\cdot 65 R^4 \beta}{\lambda} \text{ or } R_s = R \sqrt[4]{\frac{\cdot 65 \beta}{\lambda}}$$

It is assumed that the target is illuminated with the zone of greatest brightness and that the light and observer are sufficiently far apart to prevent the latter being dazzled by the former. *Table* I. (page 35) gives interesting comparative details.

For a more complete calculation we must take into account (1) the area of the target, (2) its reflecting power, (3) the absorption of the rays by the atmosphere.

The ϕ of light reflected from the target is directly proportional to its area and to its reflective power, which is defined as the ratio of ϕ actually emitted from the target to that which would be emitted if it had a perfectly white surface.

As regards (3) above, the apparent brightness of a target at range R must be decreased in the ratio $1 : (1-p)^R$, where p denotes the absorption caused by passage through 1000ˣ of atmosphere.

When lights are being tested, the magnitude of the atmospheric absorption is usually not known. The comparison of two lights must be carried out therefore at the same time and under the same conditions, as the absorption may be anything from 2 % to 50 % or even more.

It is clear then that the radius of action furnishes an extremely unreliable measure of the capabilities of a searchlight.

If one of the lights has 36 % greater brilliancy than the other, the R of the first is only 109·3ˣ greater than the R of the second, when the latter is 1369ˣ. In order to increase the R from 3284ˣ to 3612ˣ (10 %), it would be necessary to increase the *i* of the source of light by 46 %.

It is very difficult to distinguish differences in distance as small as 10 % at night when all surrounding objects are in darkness, and it is equally difficult to distinguish with the naked eye differences in illumination of a distant target as large as 30 %.

The only way, therefore, of forming a true estimate of the value of a searchlight is to carry out careful photometric measurements.

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In *Table* II. (page 36) there are given values of intensity obtained with various searchlights, partly by photometric measurements and partly by actual tests in the open. It is of course only possible to speak of approximate values in such a case as this.

For further information, the following books may be consulted :—

The Electric Arc	Mrs. Ayrton.
Illumination and Photometry ...	W. E. Wickenden.
Searchlights	F. Nerz.

to which I am indebted for much of the foregoing.

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TABLE I.

Diameter D of Mirror. cms	Focal Length of Mirror. cms	Normal Current. Amps	Diameter of Crater. m/m	β = Angle of Reflected Beam.	$\frac{D}{D_{90}}$	$\sqrt{D}$	$\sqrt{\frac{D}{D_{90}}}$	$\frac{i}{i_{90}}$	$\sqrt{\frac{i}{i_{90}}}$	$\sqrt[4]{\frac{i}{i_{90}}}$	* Relative Distances of Illum'n. Yards	Radius of Action of Searchlight. For small objects in yards †. R with conc'd Beam.	R with angles of dispersion. 10°	16°	30°	45°	For large objects in yards ‡‡ observed at Ismid.	Nürnberg.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
35	17·5	20	9	2°56′	·389	5·916	·624	·68	·825	·908	941	1674	1093	980	843	755	7650	4700
40	20	30	9·4	2°42′	·444	6·325	·666	·76	·872	·934	1149	1839	1180	1058	903	810	8320	5140
45	20	40	10	2°52′	·500	6·708	·707	·86	·927	·963	1368	2000	1312	1171	1067	903	9140	5640
60	25	60	12·1	2°47′	·666	7·746	·8165	·914	·956	·978	1870	2351	1530	1362	1160	1050	10,710	6630
60	28	70	13·5	2°46′	·666	7·746	·8165	·944	·972	·986	1904	2373	1542	1372	1170	1060	10,820	6670
75	31	80	15·3	2°50′	·833	8·66	·9128	·966	·983	·9915	2403	2660	1739	1550	1312	1192	12,100	7500
90	38	100	18	2°43′	1·000	9·487	1·000	1·000	1·000	1·000	2950	2951	1914	1699	1455	1312	13,450	8320
90	42	120	20	2°44′	1·000	9·487	1·000	1·018	1·010	1·005	2950	2951	1914	1699	1455	1312	13,450	8320
110	52	150	23	2°33′	1·222	10·488	1·105	1·066	1·030	1·015	3610	3280	2087	1860	1575	1432	14,890	9200
120	55	150	23	2°24′	1·333	10·954	1·153	1·066	1·030	1·015	4060	3445	2165	1925	1645	1486	—	—
150	65	150	23	2° 2′	1·666	12·247	1·291	1·066	1·030	1·015	4930	3762	2278	2030	1730	1563	17,500	10,786

* The distances at which searchlights of the respective diameters must be placed in order to render a target just visible when the observer's distance from the target is 2,950 yards.

† The distances at which it is possible to discover torpedo boats or to see whether artillery fire is too high or too low. For effective gun-fire reduce by 33 per cent.

‡ The distance at which it is possible to distinguish large light-coloured buildings.

‡‡ Two lights superimposed will have a range equal to that of a single light of half the dispersion.

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TABLE II.

Diameter D of Mirror.	Current.	Voltage.	Watts.	Candles per Watt.	Intensity in Candles of Rays incident on the Mirror.		Mean Intensity in Candles of Reflected Rays.	Diameter d of Crater.	Intensification of Mirror D^2/d^2.	Intensity of reflected beam in candles at great distances, neglecting atmospheric absorption.	Focal Length of Mirror f.	Angle of Dispersion.	Diameter of Beam at 1000x Distance.	Illumination in Candle-feet with absorption of 9·5°/₀ per 1000x at distances of:	
					Max.	Mean.								1093x	2187x
cms	Amps.	Volts.						m/m			cms		Yards		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
40	20	43·5	870	3·6	3130	2500	2250	9·3	1854	4,170,000	18	2°58′	51	·382	·0779
	25	44	1100	4·18	4500	3600	3240	9·4	1811	5,840,000	18	2°59′	52	·530	·01089
	30	44	1320	4·32	5670	4500	4050	9·5	1773	7,200,000	20	2°43′	47	·600	·0134
45	20	43·5	870	3·6	3130	2500	2250	9·3	2341	5,265,000	20	2°40′	46	·438	·0988
	30	44	1320	4·32	5670	4500	4050	9·5	2244	9,540,000	20	2°43′	48	·795	·178
	40	45	1800	4·63	8320	6660	5990	10	2025	12,140,000	20	2°52′	50	1·046	·226
60	40	45	1800	4·63	8320	6660	5990	10	3600	22,400,000	25	2°18′	40	1·875	·418
	50	46	2300	4·82	11,000	8820	7940	10·9	3030	24,000,000	25	2°30′	44	2·000	·447
	60	47	2820	4·98	13,900	11,100	10,020	12·1	2459	24,450,000	25	2°47′	48	2·035	·456
75	60	47	2820	4·98	13,900	11,100	10,020	12·1	3840	38,100,000	31	2°16′	39	3·165	·712
	75	49	3675	5·22	19,100	15,300	13,770	14·3	2744	38,100,000	31	2°38′	46	3·165	·712
	90	51·5	4680	5·4	25,300	20,200	18,450	16·7	2020	38,100,000	31	3° 6′	54	3·165	·712
90	60	47	2820	4·98	13,900	11,100	10,020	12·1	5532	54,850,000	31	2°16′	39	4·580	1·025
	75	49	3675	5·22	19,100	15,300	13,770	14·3	3950	54,850,000	38	2° 8′	38	4·580	1·025
	90	51·5	4680	5·4	25,300	20,200	18,450	16·7	2900	54,850,000	38	2°32′	44	4·580	1·025
	100	53	5300	5·44	28,800	23,100	20,800	17·5	2640	54,850,000	38	2°43′	47	4·580	1·025
90	125	55·5	6660	5·6	37,400	29,900	26,900	20	2030	54,850,000	42	2°44′	48	4·580	1·025
	150	59	8900	5·8	51,300	41,100	36,900	23	1530	54,850,000	42	3° 8′	55	4·580	1·025
110	150	60	9000	5·85	52,200	41,800	37,600	23	2287	86,350,000	52	2°32′	44	7·20	1·612
120	150	60	9000	5·85	52,200	41,800	37,600	23	2722	102,400,000	55	2°24′	42	8·53	1·912
150	150	60	9000	5·85	52,200	41,800	37,600	23	4300	162,000,000	65	2° 2′	36	13·48	2·700

Note :—Col. 8 × Col. 10 = Col. 11. Col. 14 = $\frac{1000 \times \text{Col. } 9}{\text{Col. } 12}$

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SOME NOTES ON ARTESIAN WELL BORING.

As the use of the artesian well for water supply is becoming daily more widely recognized, the writer has ventured to jot down these notes which are the result of experience obtained while sinking two bore holes in a division at a home station.

The wells were intended to secure to outlying forts a good supply of fresh water, and were sunk on the "trial and error" principle. The only men available were three engine drivers, none of whom had any previous experience of well boring.

The only plant available in store was a set of 1" square boring rods in 10' lengths, with 3 tools for a $3\frac{1}{4}$" bore hole—a T chisel, a clay auger, and a "shell." The latter is a tool fitted with a valve at the lower end and is designed for removing *débris* from the bore hole. A search round the other division stores, however, resulted in the discovery of a 1-ton double-geared crab with a drum 18" long by 8" in diameter. An obsolete pumping station yielded a $3\frac{1}{2}$-B.H.P. Tangye oil engine on loan, while the scrap heap was responsible for three lengths of 3" steam barrel, each about 20' long, and an old S.M. "sheaf-winding cable." The remaining gear was made in the shops or purchased locally.

The steam barrel was made into a tripod to carry the overhead gear. The detail of the head of the tripod is shown in the *Plate*, and should be noted. It is essential that the sheaf be rigidly held and not permitted to sway, otherwise the tool and rods will not drop truly vertically into the bore hole.

The crab was fitted to be driven by power and was driven continuously by the oil engine. The rope—a $2\frac{1}{2}$" manilla—was given one, two, three or more turns round the drum according to the number of rods to be lifted. The boring tool was "jumped" by "surging" the rope on the drum of the crab.

The boring table (*Fig.* 1) should be noted. This is fitted with a removable "auger board," cut from $\frac{3}{8}$" boiler plate. This auger board is fitted with dowel pins so that it is held rigidly in position. It guides the rods and also takes the weight of the dogs, when raising and lowering the rods. The method of operating will now be detailed.

The crew for boring consists of one N.C.O. and two sappers. The N.C.O. directs operations, looks after the engine, and works the fall

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BORING TABLE
WITH REMOVABLE AUGER BOARD.

Scale—$\frac{1}{8}$ Inch to 1 Foot.

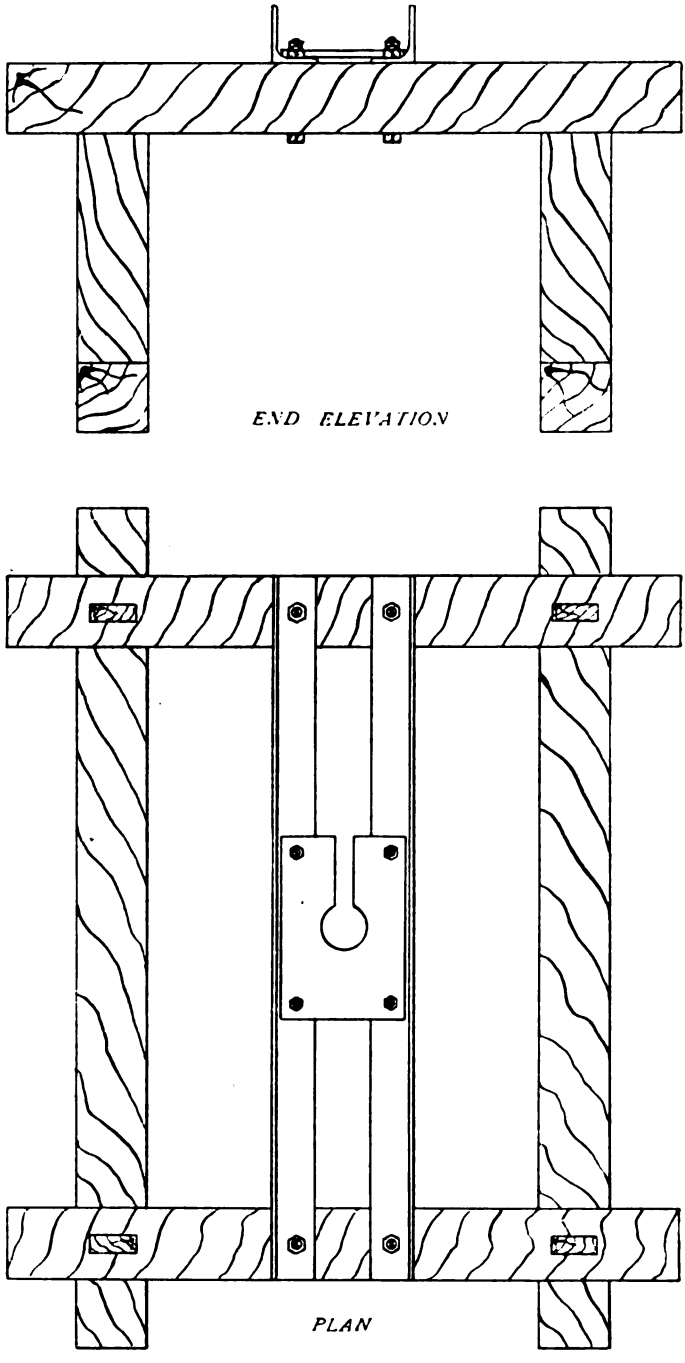

FIG. 1.

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of the rope at the crab. The two sappers stand by the boring table to manipulate the rods and boring tools.

The rods and tools are all laid out in order side by side so that they can be easily selected as required. The male ends of the rods and tools towards the bore hole are supported clear of the ground to facilitate picking them up quickly.

It must be borne in mind that the rate of boring is largely dependent on the speed of manipulating the rods and tools, and also on the peripheral speed of the drum of the crab. In this connection it may be remarked that at first the crab drum was driven at a peripheral speed of about 35′ a minute, but when the crew had gained experience different pulleys were substituted, making the speed some 65′ a minute which seemed a fair average rate.

The rods should always be kept in the same order so that the same male and female ends come together. Interchange of the screwed ends causes undue wear.

To detail the actual operation of boring, let us suppose the hole is 40′ down, and has just been cleaned out. The strata encountered is hard. Sappers A. and B. are manipulating the tools while Corpl. C. drives the crab. Sapper A. takes a lifting dog and drops it over the swelled end of the **T** chisel (or any other tool which may be selected), and places the chisel down the hole until the dog rests on the auger board. Note that all tools and rods should invariably be handled by means of the lifting dogs when boring or clearing operations are in progress. If this precaution is neglected a tool may be dropped down the bore hole. Having thus got the tool in position, Sapper A. hands the spring hook, with another lifting dog attached, to Sapper B., who places it round the shoulder of the lowest rod which always comes at the bottom above the tool. Sapper A. then signals to Corpl. C. to hoist, which rears up the rod to a vertical position and brings the end over the tool. Sapper A. then screws down the rod on to the tool, using the hand wrench for the purpose, signals for the crab to hoist and removes No. 1 lifting dog which permits the tool to be lowered until No. 2 dog comes in contact with the auger board. No. 1 dog is next used again to lift another length of boring rod in position, and so on until the bottom of the bore hole is reached. The swivel-topped rod is then put on and the tillers for turning the rods fixed. The tool is jumped up and down in the bore, by surging on the drum of the crab. The tillers are kept turning round in order that the hole may be truly circular. When the tool has dropped a foot it is withdrawn and the *débris* removed with the shell.

In soft soils, sand or gravel, it is necessary to line the hole, to prevent the sides falling in. The best form of lining is undoubtedly the socketed type, with sockets levelled at each end. The blow of the monkey then drives on the ends of the pipe and not on the threads, as is the case if swelled end pipes are used. The lining

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should be in convenient lengths; 6′ lengths were used in this case. A driving cap should be used in order to prevent the monkey damaging the threads of the pipe. The lining is driven as the boring proceeds, using the monkey attached to the spring hook.

When water is struck the supply is tested by lowering a deep well pump down the bore by means of the delivery pipe, which in this case was ordinary 2″ galvanized iron in 10′ lengths. The pump rod was ½″ galvanized iron also in 10′ lengths working inside the delivery pipe and lowered at the same time. An old barrack pump with crank and fly wheel was used to couple to the ½″ rod, and arranged with a pulley to be driven by the engine. The supply obtained with the 3¼ bore hole was 200 gallons per hour continuously during the six hours' trial in one hole, but with the other no water was obtained after 90′ of boring, and the strata did not seem to point to success and the hole was abandoned.

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THE TORSION BALANCE OF BARON EÖTVÖS.

By MAJOR E. H. HILLS, C.M.G., F.R.S., LATE R.E.*

THE torsion balance, developed as a practical field instrument by Baron Eötvös, is likely to prove of great importance in the higher branches of survey work and may fairly be said to place a new power in the hands of the geodesist. The function of the instrument is the determination of the local variation of gravity on the earth's surface.

Hitherto there have been two methods available for this research; one by pendulum observations whereby the value of g is found at any place and the other by a comparison, at a large number of stations, between geodetic and astronomical positions, thus finding the deviation of the plumb line, or the angular quantity by which the apparent vertical differs from the true normal to the spheroid. The direction and amount of the resultant horizontal component of the force of gravity at each station is thus deduced. The torsion balance is now available for checking and supplementing the information given by the older methods.

It arrives at the same results by a different route. Its function is not the direct evaluation either of g or of the variation of the level but, in place of these, it serves to determine the differential co-efficient of the force of gravity, *i.e.* its rate of change along any selected horizontal axis.

Thus suppose the value of g has been found at any two stations by the use of the pendulum; if now we determine the rate of change of g by the Eötvös balance along a series of intermediate points we shall have two values, of independent origin, for the difference in the force of gravity at the two original stations. A similar research would give us an independent value for the difference in the deflection of the plumb line at the two places.

Of these three methods now available for the investigation of anomalies in the distribution of rock masses in the earth's crust the advantages will lie with one or the other according to the particular character of the anomalous distribution and their mutual comparison will lead in every case to the best determination of the positions of the perturbing masses. The torsion balance is working

* Expanded from a "Note on Points connected with the Progress of Astronomy"; Monthly Notices, Royal Astronomical Society, LXXI., 4. February, 1911.

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under the most favourable conditions when the masses are nearest the surface and it is not inconceivable that in addition to its use by the geodetic surveyor it may in the future find employment, of a severely practical nature, for the location of ore deposits. A somewhat analogous research has actually already been undertaken in the shape of a comparison between the perturbations due to gravity and those due to magnetic attraction, thus elucidating the distribution of magnetic masses and of those of high density but non-magnetic. The presence of masses of iron can thus be deduced.

The theory of the instrument is readily expressed in analytical form but the following considerations will enable the reader to understand its general principles without recourse to symbols. Imagine a torsion balance of the ordinary form, such as used in the "Cavendish" experiment, *i.e.* a light rod with equal weights at each end hung horizontally by a fine thread attached at its middle point, the upper end of the thread being fastened to a "torsion head" capable of being turned horizontally through any measured angle. Imagine further that the apparatus is placed at a station where there is no local attraction.

The thread will hang vertically downward in the direction of the resultant force of gravitation and, the distribution of the earth masses in the neighbourhood of the instrument being symmetrical or, in other words, the field of force round the instrument being uniform, the beam is under no constraint towards any particular azimuth, so that, suppose the beam to have come to rest in any position, if the torsion head, carrying the thread, be turned through any angle, the beam will turn through the same angle.

If, now, the symmetrical distribution of gravity is disturbed, say by the presence of an attracting mass of rock, giving rise to a horizontal component in the force of gravity, the thread will still hang vertically, but this "vertical" will be inclined to the original direction at a small angle, called the deviation of the plumb line. The beam can no longer assume any azimuth with equal facility. There are now two directions, one when the beam is in the line joining the instrument with the centre of action of the horizontal force, and the other when it is at right angles to this line, where the beam can come to rest with the thread untwisted. In any other azimuth there will be a residual twisting of the thread, so that if the torsion head be now turned through any angle the beam will not in general follow it through the same angle.

By turning the torsion head through successive angles of 45°, 90°, 135°, etc., and by noting the corresponding positions at which the beam comes to rest, we can map out the rates of change of the gravitational forces along any selected horizontal axis, and determine the direction of the resultant horizontal component.

Instead of noting the rest positions of the beam we can take

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advantage of the fact that the change in the horizontal force will affect the time of swing of the beam in the same manner as the time of vibration of an ordinary vertical pendulum is changed with a change in the value of g, so that we can derive the required information by noting the vibration period in different azimuths. As however to give the requisite sensitiveness this period must be large, in the case of Eötvös instruments it is not less than 10 minutes, this alternative method would be too slow for field use.

It will thus be seen that the essential features of the method involve no new principle. The great achievement of the inventor lies in the transformation of an instrument of an ultra-sensitive nature, only capable of use in a laboratory with every possible shielding from external disturbance, into a portable instrument adapted for use in the field.

The extreme minuteness of the quantities revealed by the torsion balance can best be realized when we remember that we are, in effect, measuring the torsional couple due to the difference in the attraction of the horizontal component of gravity upon the weights at the two ends of the beam respectively. The horizontal component is already itself very small, except in altogether abnormal places, so that, without going into figures, it is sufficiently obvious that this difference is near the limit of instrumental observation. The close accord of the results actually obtained by Eötvös in the field, both among themselves and in comparison with those arrived at in other ways, shows that the measurement lies well within the power of the instrument as designed by him.

In the actual instrument the beam is a thin brass tube, 40 centimetres long with platinum weights at each end, hung by a fine platinum-iridium wire, the whole contained in a double-walled brass case. The angular deviation or rest position of the beam is read off by a minor reflecting a spot of light. It has not yet been found possible to use the instrument except at night, in the daytime the temperature disturbances are too great.

It is interesting and important to note that sensitive as the instrument has proved to be its present form by no means marks the limit of sensitiveness. This could be largely increased by a diminution in size, accompanied by a change in the means of suspension from platinum wire to a quartz fibre, transforming the instrument in the same sense as the original Cavendish instrument was transformed by Prof. C. V. Boys in his classical determination of the mean density of the earth (*v. Encyl. Brit.*, article "Gravitation"). It is understood that Baron Eötvös is himself experimenting with a new instrument upon these lines.

A special investigation, to which the apparatus has been applied by its inventor, is to answer the question as to within what limits the constant of gravitation is the same for all bodies. If it is not, the

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direction of the apparent vertical will vary with the material of the plumb-bob, since the observed weight of any body is the resultant of two forces, the attraction which for two different bodies would have the same direction, but, on this assumption, a different intensity, and the centrifugal force which would have the same direction and the same intensity for every body.

Previous observations with the pendulum had shown that there was no difference greater than 1/60,000; with the torsion balance Eötvös has shown that any difference cannot exceed 1/200,000,000. Laplace investigated this question astronomically by comparing the Sun's attraction upon the Earth and Moon respectively, and found that any difference was smaller than 1/1,000,000. His calculations remade with the data now available give 1/50,000,000.

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DECAY OF BUILDING MATERIALS IN EGYPT.

By Capt. D. M. F. Hoysted, R.E.

When investigating the decay of buildings which is so noticeable in Egypt, two points are specially striking, firstly that the action is generally confined to a band extending to about 5′ above the ground line, or is greatest at or near that level, and secondly that it is often accompanied by a white crystalline deposit or efflorescence.

Further it is noticeable that the disintegration is brought about by the chemical deposits forming just below the superficial layers of stone which force them away from the mass.

A very extreme case of this kind has been seen by the writer in one of the barracks situated on the seashore at Alexandria. In the local Mineral Water Factory carbonic acid gas is used for aerating the waters, and is generated in a leaden vessel from carbonate of soda and sulphuric acid. The walls in the factory are about 2½′ thick and consist of native soft stone and mortar in rubble masonry faced with ¼″ of plaster. It was noticed lately that the plaster in the vicinity of the generator was beginning to bulge and flake off, dropping from the wall in large sheets. The surface of the stone below was covered with a crystalline growth resembling white hairs pointing stiffly at right angles from the face of the wall. The surface was thoroughly scraped and left under observation.

In about five days, fresh crops of the white hairs had formed, and in 10 days' time they were an inch in length and in places the fine needles stood almost as closely together as the pile of a carpet.

A chemical examination proved them to consist almost entirely of sodium sulphate with a slight admixture of sodium chloride. The old native walls are nearly always built of sand from the neighbouring seashore and contain therefore a large amount of sodium chloride. It appears that the quite unnoticeable acid fumes, from the generation of the gas for aeration, have a very active effect upon the salt in the masonry, forming crystals of sodium sulphate just below the surface.

This is borne out by some experiments made by Mr. A. Lucas, F.C.S., in 1902, from which he concluded that, in the case of building materials in Egypt, in addition to the disintegration caused by changes of temperature, the oxidizing action of the atmosphere and the corrosive action of acids present in the air or rain, there is also

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considerable detritus, most frequently near the ground level brought about by :—

(1). The presence of moisture.
(2). The degree of porosity of the stone.
(3). The presence of salts readily soluble in water, either in the stone or the neighbouring ground.
(4). The opportunity for the salts to crystallize out by evaporation of the water holding them in solution.

His opinion was that this special kind of disintegration is largely physical, and that the essential conditions consist of the presence of water, soluble salts and a porous stone.

In all native walls in Egypt the typical scaling of the outer surface is noticeable within a year of completion, and, if uncorrected, it will eat completely through the wall in time just above the ground level. The local stone is very soft and porous and readily absorbs moisture from the rain or mist, and is therefore invariably covered with a plaster for protection. This plaster, must, however, be renewed as it falls away.

I venture to bring this report forward, though, of course, the special case quoted at the beginning is quite of an exceptionable nature, being undoubtedly caused by the acid fumes, as the walls in the same room but at a distance from the generator, are unaffected.

I should be glad to know, if a petrifying liquid has ever been tried as a preventive in such case.

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TRANSCRIPTS.

FRENCH REPORT OF THE COMMISSION ON THE PROPOSED BUDGET FOR 1911—WAR DEPARTMENT.

This transcript deals only with the parts of the above report which refer to the engineer troops of the French Republic.

(1). Pay of the Engineers.

Sum voted for 1910	4,168,783 fr.	+229,803 fr.
Sum asked for by the Government for 1911	4,398,586 ,,	
Sum proposed by the Commission	4,398,586 ,,	

(i.). *Details of Increases.*

New billets for N.C.O.'s in aircraft and telegraphy and the detachment of electricians and mechanics	15,971 fr.
Increases of pay and allowances for extra cost of living	7,370 ,,
Increase of subalterns' pay	144,456 ,,
Increases for extended men	53,518 ,,
Increase of captains' pay	20,000 ,,
Allowances to N.C.O.'s in charge of wireless stations	5,490 ,,
Increase of the number of pupils of the "Ecole des Ponts et Chaussées" doing their second year there as second lieutenants of the reserve ...	33,661 ,,
Increase of the establishment of reservists and territorial troops to be called out in 1911 ...	11,209 ,,
Calling up of the military telegraphy sections ...	3,000 ,,
Increase of various previous grants	8,917 ,,
Transfer to this vote of the sums allotted for the military instruction of the pupils of the "Ecole des Ponts et Chaussées"	585 ,,
Total increases...	304,177 fr.

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(ii.). *Diminutions.*

Variations in the establishment and pay of officers paid under this vote...	42,509 fr.
Decrease in the establishment of rank and file ...	4,865 ,,
Variations in the establishment and rank of the reserve and territorial officers to be called out in 1911	5,563 ,,
Transfer to another vote of officers' horse allowance	9,937 ,,
Transfer to another vote of the cost of first outfit granted to pupils of the "Ecole des Ponts et Chaussées" on first appointment as second lieutenants	11,500 ,,
Total decrease	74,374 fr.
Net total increase	229,803 fr.

a. New Billets for N.C.O.'s in Aircraft, Telegraphy and the Detachment of Electricians and Mechanics.

	Sergeants.	Junior N.C.O.'s.
Aircraft	12	—
Wireless telegraphy	19	7
Electricians and mechanics	20	18
Total	51	25

These increases are justified in the aircraft department by the fact that the French have 4 dirigibles and 2 cruisers, each with two crews of 2 sergeant mechanics and in the wireless by the strength of the detachment 75 men.

b. N.C.O.'s in Charge of Wireless Stations.

These are N.C.O.'s who have extended their service to whom the following daily allowances are granted :—

1st Class stations (6 in all)	3 fr.	(Yearly billet).
2nd Class (6 in all)	2 fr. 50	For 3 months in the year.
3rd Class (8 in all)	2 fr.	

c. Special Allowances to Aviators.

These are as follows :—

(*a*). Soldiers on duty, when going up in balloons, dirigibles, or aeroplanes, will receive in addition to the ordinary travelling allowances, special allowances at the following rates :—

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Rank.	Time in the Air.	Allowance.		
		Balloon.	Dirigible.	Aeroplane.
Officer, Q.M.S. or attached civilian	½ to 2 hrs.	3 fr.	5 fr.	5 fr.
	2 to 6 ,,	5 ,,	10 ,,	15 ,,
	Over 6 ,,	10 ,,	20 ,,	25 ,,

Sergeants, junior N.C.O.'s or men :—Half of the above amounts.

This allowance is not really intended to compensate the men for the risk they run, but rather as an increase of travelling allowance.

The length of the flight is certified by the senior officer. The time of the flight is the total of the times spent in the air on the day of the flight. No grant is allowed for flights of less than 5 kilometres, but for a single flight of 5 kilometres, officers, etc., receive 5 fr. and sergeants, etc., 2 fr. 50.

(*b*). Air pay will be granted at the following rates to :—

(1). Extended or attached officers or N.C.O.'s serving with the air troops or undergoing courses of instruction.

(2). Officers or N.C.O.'s serving beyond their legal time of service as pilots or learners :—

Rank.	Daily Rate.
Field officers or attached civilians	2 fr. 50
Subaltern officers or attached civilians	1 fr. 50
Government civilian employés, Q.M.S.'s	0 fr. 75
Other N.C.O.'s	0 fr. 40

(2). Engineer Establishments (Personnel).

Sum voted for 1910 ... ... 1,189,775 fr.
Sum asked for by the Government for 1911 ... ... 1,167,775 ,, } — 22,000 fr.
Sum proposed by the Commission ... 1,167,775 ,,

Details of Increases.

Increase of the pay of technical engineer R. & F. ...	2,400 fr.
Range warden at the camp of Coetquidan	1,500 ,,
Allowances to one barrack warden	50 ,,
Transfer from another vote of the pay of Q.M.S.'s in charge of motors at wireless stations and of military pigeons	1,500 ,,
Increase of pension to workmen	1,750 ,,
Total	7,200 fr.

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Details of Diminutions.

Transfer to another vote of the extra pay of engineer Q.M.S. clerks	29,200 fr.
i.e. Total net diminution	22,000 ,,

The only item requiring explanation is the creation of the post of range warden at the camp of Coetquidan. This range is in the charge of a Q.M.S. acting as D.O. Lands, and is so far from his house, that he is unable to devote that constant care to it which it requires, a range warden has therefore been instituted to keep tramps from the Government buildings on the range and camping ground.

(3). ENGINEER ESTABLISHMENTS (MATÉRIEL).

Sum voted for 1910	13,797,970 fr.	
Sum asked for by the Government for 1911	14,000,680 ,,	+ 202,710 fr.
Sum proposed by the Commission	13,964,680 ,,	− 36,000 ,,

Details of Increases.

Increase in the first cost of materials and labour ...	5,000 fr.
Dismantling of the fortress of La Rochelle	36,000 ,,
Maintenance of certain buildings used as barracks...	45,000 ,,
Increase of the aircraft and telegraphic services ...	62,560 ,,
Instruction of officers of all arms attached to the air troops	31,250 ,,
Addition training grant for engineer troops... ...	6,400 ,,
Additional for maintenance of *matériel* and tools ...	18,000 ,,
Total increase	204,210 fr.

Details of Diminutions.

Transfer to another vote of the allowances of Q.M.S.'s in charge of motor at wireless stations and of military pigeons	1,500 fr.
Remaining increase ...	202,710 fr.
Reduction effected by the Commission	36,000 fr.

(*a*). The dismantling of the fortress of La Rochelle consists in the removal of old works on plots of ground allotted for the training of troops. The dismantling of the fortifications on those plots of ground given to the town is carried out at its expense not at that of the War Department. The buildings used as barracks which have to be maintained are mainly seminaries. The sum allotted for this purpose is 1% to 2% of their value.

(*b*). Of the 62,560 fr. for the increase of the telegraphic and aircraft service 42,360 fr. are allotted to aircraft and the remainder to telegraphy,

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chiefly to cover the expenses of the new field wireless stations and telephone material of the infantry.

(*c*). The 31,250 fr. for the training of officers of all arms in aeronautics enables :—

(1). Twenty officers to undergo a course of instruction in ballooning for four months.

(2). Eight officers to undergo later a course of one month in ballooning, consisting chiefly of free runs. These officers must have passed the first course.

(3). Five officers with the necessary qualifications to undergo a seven months' course as dirigible pilots.

(*d*). The 18,000 fr. for the maintenance of *matériel* and tools is to pay for the supply of mobilization materials necessary for field and fortress engineer units, which is to be increased, and to upkeep the additional tools issued to the infantry and the light bridging equipment issued to cavalry regiments.

(4). Technical Engineer Staffs.

The chief items under this heading are the increase of 12 engineer captains and 3 Q.M.S. foremen of works. The pay of the Q.M.S.'s has also been increased.

(5). Barracks.

Sum voted for 1910	7,000,000 fr.	+ 2,000,000 fr.
Sum asked for by the Government for 1911	9,000,000 „	
Sum proposed by the Commission	9,000,000 „	

The 2,000,000 fr. is to be allotted to the construction of barracks for the new artillery units created by the law of the 25th July, 1909, together with a proportion of the old 7,000,000 fr.

(6). Fortifications.

Sum voted in 1910	12,042,000 fr.	− 1,000,000 fr.
Sum asked for by the Government for 1911	11,042,000 „	
Sum proposed by the Commission	11,042,000 „	

This money is to carry on the fortification of the places on the N. and N.E. frontier, in the Alpine districts and along the coasts.

(7). War Matériel of the Engineers.

Sum voted in 1910...	3,970,000 fr.	+ 3 600,000 fr.
Sum asked for by the Government in 1911	7,570,000 „	
Sum proposed by the Commission	7,570,000 „	

The increase is entirely due to the aircraft service, *i.e.* the building of new dirigibles and the provision of material for all branches of aviation.

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(8). USE OF AEROPLANES AND DIRIGIBLES ON MANŒUVRES.

An increase of 50,000 fr. has been granted to carry out the above.

(9). INCREASE OF THE NUMBER OF ASPIRANT OFFICERS AT THE MILITARY SCHOOL OF THE ARTILLERY AND ENGINEERS.

There will be an increase of one aspirant officer for the engineers allowed for this school.

NOTE.—All through this paper the English rank Q.M.S. has been used to interpret the French rank "Adjutant" for which no adequate translation exists.

A. H. SCOTT.

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AIRSHIPS: EXPERIMENTS WITH BEACON LIGHTS, ETC.

(From the *Hamburger Nachrichten*, 20th December, 1910).

WE are informed that experiments are about to be carried out, by the Airship Battalion, with certain beacon lights intended to facilitate the steering of airships, by night. Two beacons or lighthouses have been constructed experimentally at the Spandau Railway Station. One is electric-automatic, while the other is an intermittent light.

The electric light consists of a wooden ring, 5 metres in diameter, which is mounted on the roof of a building. The 30 watertight 50-candle-power carbon filament lamps, carried on the ring, stand up vertically towards the sky. The device is controlled by a triple pole main switch, and a current of 220 volts is used.

The intermittent light, which is similar to that of an ordinary lighthouse, is of special interest. The system of vertical lines (planes) is used, which—by means of refraction and reflection—concentrate the rays and emit them parallel. In the case of lighthouses for aerial navigation, it is necessary that the beams of light should be visible from the horizon to the zenith and all round the horizon. For this reason a dome-shaped *Fresnel* lense with a focal distance of 187·5-m.m. (7·38″) has been used, such as are used with light buoys at sea. The lenses revolve so as to send a bright light in all directions such as will be visible as an intermittent fan-shaped beam to an airship at any elevation. In order to utilize rays of light falling below the horizontal plane, prisms placed below that plane deflect the light upwards. Various forms of gas (coal, acetylene, etc.) are utilized as illuminants.

The range, over which the light can be seen, is, in round figures, 12 miles. The employment of electric arc lights with *Fresnel* lenses of 300 m.m. (11·8″) focal length would increase the range to double that distance.

H. H. DOWDING.

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REVIEW.

FOR REMEMBRANCE AND IN HONOUR OF THOSE WHO LOST THEIR LIVES IN THE SOUTH AFRICAN WAR, 1899—1902.

By COLONEL SIR JAMES GILDEA, K.C.V.O., C.B., 4th Royal Warwickshire Regiment, Chairman and Treasurer of the Soldiers' and Sailors' Families Association.—(Price £2 2s.).

THIS is a handsome volume in which Sir James Gildea has compiled a short description of 900 Memorials, with illustrations in most cases, erected to the memory of those who lost their lives in the above-named war. It is a work which must have given the Editor a vast amount of trouble, and although not claiming to be a complete record, is very comprehensive. Practically the whole of the illustrations are reproduced from photographs printed on excellent paper and thus giving a good idea of the appearance of the various subjects chosen to perpetuate the memory of those who fell in the War. Sir James Gildea has not included in his book those monuments which have been erected to chronicle the part individuals of certain districts took in the campaign.

The profits on the sale of the book will be devoted to the Royal Homes for Officers' Widows and Daughters at Wimbledon, in connection with the Officers' Branch of the Soldiers' and Sailors' Families Association.

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NOTICES OF MAGAZINES.

Revue Militaire des Armées Étrangères.

September, 1910.

Foreign News of Divers Countries.—*Austria.*—By a decision of the 10th August, 1910, the engineer section of the Military Technical Academy has been divided into two parts, the pioneer class, and the class for the communication troops. From 1913, no cadet from the Pioneer Cadet School will be posted to the telegraph or railway units of the engineers, the officers of which will be only drawn from the communication troops class of the above-mentioned Academy.

Italy.—The reorganization of the army, as effected by the law of the 13th August, 1910, will be as follows:—

(1). General Staff, including:—The chief of the general staff; four general officers who in war will command armies; twelve army corps, 25 divisional and 3 cavalry divisional commanders; all other general officers.

Two commissions have also been created by this law:—The Army Council, and the Superior Defence Committee.

(2). The Staff.

(3). Infantry, including:—An inspector of mountain troops, with his staff; forty-eight infantry brigade headquarters; three Alpine brigade headquarters; two grenadier regiments; ninety-four line regiments twelve regiments of Bersaglieri; eight Alpine regiments. The recruiting officers of territorial districts are drawn from the auxiliary forces.

(4). Cavalry, including:—An inspector-general of the cavalry, with his staff; three cavalry divisional headquarters; eight cavalry brigade headquarters; twenty-nine cavalry regiments; remount depôts and stud farms.

(5). Artillery, including:—An inspector-general of artillery and staff; an inspector of artillery *matériel*; nine field artillery headquarters; four fortress artillery headquarters; thirteen artillery staffs; thirty-six field artillery regiments; one horse artillery regiment; two mountain artillery regiments; two heavy artillery regiments; ten fortress artillery regiments; one experimental staff; artillery material factories; remount depôts.

(6). Engineers, including:—An inspector-general of engineers and staff; two engineer headquarters; five territorial engineer headquarters; six engineer regiments (24 battalions, 69 companies, 6 depôts); one specialist battalion of 5 companies; 10 transport companies; 12 engineer staffs, 14 sub-staffs, and fortification committees as required (not yet formed); engineer *matériel* factories.

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(7). The existing commissariat and pay departments are to be abolished and replaced by:—(*a*) A new commissariat corps, consisting of an inspector of transport and supplies and his staff; twelve staffs; commissariat offices; supply officers; twelve supply companies; (*b*) an administrative corps.

October, 1910.

THE SERVICE FOR TWO YEARS IN ITALY.—On the 11th February, 1910, a Bill suggesting the service of two years was brought up before the Italian Parliament, and it became law on the 30th June of the same year.

The question of reducing the time of service from three years (four in the cavalry) had already been under consideration for some time, and had actually been tried in 1909, when the "1887 class" had been dismissed after two years, as the supply of recruits was sufficient to keep the army up to peace strength, and the non-dismissal of this class would have involved an increase of establishments.

According to the old Recruiting Act of 1888 the Italian Army consisted of three classes of men:—(1). Those who served their whole time. (2), Those who served from two to six months and served to keep the units up to peace strength. (3). Those who were exempted from all service.

In 1907, the third category was almost entirely done away with and the numbers of the first greatly reduced by increasing those of the second; the peace establishments of the units remaining the same.

The way was thus slowly prepared for the reform which was to follow.

Consequent on the reduction of the time of service certain reforms were considered necessary. These were:—(1). That the training would have to be more arduous. As the Italian soldier is very quick, both mentally and physically, this was considered to offer no difficulty. (2). The army would have to give up the police duties it had hitherto undertaken. An increase of three battalions of carabinieri will, it is hoped, make up for this deficiency. The length of service in the "carabinieri" remains five years, and that of the customs troops, three. (3). The soldier servants granted to certain classes of officers are to be done away with, and these officers granted an allowance in lieu. Further, the cavalry soldiers will in future only be used as bâtmen to the officers by their own regiment. (4). Garrison battalions (battiglioni presidiari) are to be formed for permanent works.

Cavalry.—The length of service in this arm is to be two years only, but the men are to be specially chosen and not to be sent to this arm by chance drawing.

On certain questions which arose, the following rulings were given:—

(1). The peace strength of the cavalry was not to be increased from 13,000 to 15,000 men, as the North of Italy is not suited to the employment of large masses of cavalry.

(2). The training of all recruits by a special staff, and not in their squadrons, was also disapproved of as tending to destroy the personal influence of the captain on his men, and this influence is considered as one of the most essential elements of military education.

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(3). About 2,400 remounts are annually required by the cavalry, and 700—800 by the artillery. These are sent from the State stud farms, and in view of the reluctance of Italian soldiers to re-engage after their time of service is over, it was decided to re-enlist the *personnel* of these stud farms from old troopers and gunners, and not to attempt to induce men to re-engage. The number of men required for this purpose is 1,200.

Cadres of N.C.O.'s.—This very important question is not yet entirely settled. At present it is suggested to increase the strength of mounted units by two N.C.O.'s; to promote to the rank of corporal, in the dismounted units, those men who enlist three months before they are due.

One-Year Volunteers.—The system of one-year volunteers has not been abolished.

General Remarks on the Innovation.—The peace strength of the army will be 250,000 men. It is expected that this reform will better the moral and physical conditions of the rank and file. The age of the army in general will be reduced, the oldest reservists being 28 years old.

Military News of Divers Countries.—*Germany.*—Officers of the three arms are in future to be attached to the railway and telegraph troops for one year as follows :—

Infantry, a lieutenant and a second lieutenant to each railway regiment, and two lieutenants and two second lieutenants to each telegraph battalion. *Cavalry and artillery*, three lieutenants and three second lieutenants to each telegraph battalion.

(2). An aviation section of the experimental section of the communication troops has been formed.

(3). Two large telegraph troop exercises were carried out last August. The first, for wireless troops, only lasted six days. The four battalions taking part practised the communications of several armies on the same theatre of operations. The second exercise was carried out by the ordinary telegraph units and lasted five days. It consisted of practising the internal communications of the larger units.

Italy.—The Alpine troops are to wear the grey-green uniforms at all times, whether in the field or in garrison.

A new law has been passed on the subject of emigration, the *résumé* of which is that Italians, living out of Europe and under 16 years of age, will, if still living abroad, be exempted from military service. If they return to Italy before the age of 32 they have to serve, if they are older they are exempted. Italians living in Europe must report to the nearest consulate or legation, to be medically inspected when the time comes for them to do their period of service. According to the result of this examination they will be obliged to serve or be kept back.

December, 1910.

(1). Recent Modifications in the Russian Army.—The most important of the reforms which have taken place in the Russian Army since the Russo-Japanese War, is, without doubt, the entire abolition of the infantry reserve and fortress formations, and their transformation into

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formations of the active army. This reform has just been made final by the distribution tables of the army dated 14th October, 1910.

The original existence of the reserve and fortress formations was fully justified by the bad communications and great extent of the Russian Empire. It was however found that, on mobilizing the army for the Russian-Japanese War, a large number of men were immobilized by bringing these formations up to war strength, and could thus be employed only as second line troops, though badly wanted in the front line. Their abolition was accordingly demanded from 1906 onwards by most military writers. The result of the reform for the infantry is as follows:—

	October, 1908.	October, 1910.
Active Battalions	1,086	1,260
Reserve Battalions	176	*Nil.*
Fortress Battalions	56	*Nil.*
Total	1,318	1,260

The diminution of 58 battalions on the total is made up for by the strengthening of establishments and cadres of the active formations.

As a natural result of the increase of the infantry, the field artillery had to be increased, and has now been raised to one brigade of field artillery (six 8-gun batteries) per division, and three 6-gun howitzer batteries per army corps of two divisions. An artillery group of three 8-gun batteries is attached to each brigade of skirmishers, and a group of two horse artillery batteries of six guns to each cavalry division. Seven heavy artillery groups have also been created. The mountain artillery groups are no longer independent, and are attached as extra artillery to various brigades. The mountain horse artillery groups alone conserve their autonomy. There still exists one horse artillery depôt, which is allotted on mobilization to the cavalry depôt, and, in Siberia, a few artillery parks. The total increase is 54 mobile batteries, and one fortress artillery battalion. The C.R.A.'s of divisions have been given the new title of inspectors of artillery.

Cavalry.—A new division has been formed.

Engineers.—The more technical troops, wireless telegraphy, air troops and railway troops have been increased, but the other field engineer units remain practically unchanged in number. The engineer parks have been abolished as a peace formation, and the number of engineer siege trains increased by one.

The total increase since 1908 of the active divisions of the army is:—Infantry.—(1908), 69; (1910), 78½ = increase 9½ divisions. Cavalry.—(1908), 27; (1910), 28 = increase 1 division.

MILITARY NEWS OF DIVERS COUNTRIES.—*Austria-Hungary.*—An increase in the estimates of 50,350 crowns has been granted to the aeronautical establishments, and one of 33,719 crowns to the telegraph school, with a view to creating a special radio-telegraphic section for experimental work.

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Germany.—Courses of instruction in the care and preservation of arms and bicycles, and in the use of range-finders took place last winter in the military arsenals of Spandau, Dantzig and Erfurt. The number of officers attending these courses was 109 subalterns. Their duration was 20 working days.

Spain.—An experimental committee for engineer *matériel*, consisting of one colonel, one lieutenant-colonel, two majors, and three captains has just been instituted.

Italy.—Special grants to aviators and military aeronauts. The following scale of grants to officers, N.C.O.'s and men, or other workmen employed in any free flights or voyages in dirigibles has been approved of :—Officers.—20 francs per ascension. N.C.O.'s.—10 francs. Men.—5 francs. The same scale applies for flights in aeroplanes or kites.

(2). An aviation section has been formed and attached to the engineer balloon battalion. Its strength is as follows :—1 captain, or lieutenant, commanding; 3 company officers. An indeterminate number of attached officers, 15 N.C.O.'s, 50 men.

The Swedish Autumn Manœuvres of 1910.—A complete description of these manœuvres is given; the following are extracts from the comments on the operations :—(1). For the first time the systems for the supply of ammunition and food were seen at work. (2). The captive balloon—an elliptical German model—made numerous useful observations. (3). The bridging train carried out its work well. (4). During the last two nights the searchlight sections were employed. (5). The telegraph and telephone services worked very well. (6). The Swedish horses are very good. The tactical employment of the cavalry gave rise to some peculiar situations, this arm being used independently of the others. (7). The whole medical service was as for active service, and carried out its work very well. (8). The sanitary state of the troops was good; the weather cold and on one occasion rainy.

Military News of Divers Foreign Countries.—*Austria.*—Ski courses, which last for about one week, are being arranged for officers of the General Staff, and also courses lasting 13 days for reservists of the infantry and rifles.

(2). The war ministry has decided to purchase three aeroplanes for the army, the desiderata being :—(1). That the machine shall make a flight of two hours at a speed of 70 kilometres per hour. (2). Make a similar flight with a passenger on board, the total weight carried not to be less than 210 kilograms. (3). The machine must be such that it can be taken to bits in one hour, and put together again in two hours, and further be transportable on an automobile.

(3). Two new dirigibles have been bought by the Austrian Government :—The Lebaudy-Juliot, 60 metres long and with a capacity of 3,700 cubic metres; and the Boehmer, 57.5 metres long and with a capacity of 2,750 cubic metres. The former is of the semi-rigid and the latter of the non-rigid type.

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China.—An Admiralty has been created with Prince Tsai-Suen, the younger brother of the regent, as Lord High Admiral. He is assisted by an under-secretary of state, and the ministry will be divided into a head-quarters staff of nine sections:—(1). Centralization. (2). Administration. (3). Technical matters. (4). Legislative affairs. (5). Coast defence. (6). Sanitation. (7). Music. (8). Supplies. (9). Pay. The fleets are to be distributed as follows:—(1). Fleet of the north or Peiyang. (2). Fleet of the south or Kwangtung. (3). Fleet of the centre or Yang-Tse.

Germany.—There are 40 holders of aviators' certificates in the German Empire, of which 8 are officers of the active army. At the military school of flying at Doeberitz, there are 10 officers undergoing a course of flying. Their aerial education will not be considered as complete until they are fully qualified to act as pilots to the following machines:—Wright, Albatross (two types), Farman, Rumpler, Grade and probably Dorner. They will then be entrusted with the duty of acting as instructors to the rest of the army.

Spain.—The strength of the army is fixed, for 1911, at 115,432 men. The pay of majors and colonels has been slightly increased.

Italy.—Four offices, of the Generals designed in time of war to command an army, have been instituted, and will be at Rome, Florence, Milan and Naples. They will temporarily consist of:—1 lieutenant-colonel or major on the General Staff. 1 lieutenant attached (not seconded from his unit). 1 infantry or cavalry lieutenant or 2nd lieutenant (galloper, also not seconded).

Japan.—The following are extracts from the new organization of Korea, since its annexation:—(1). The Governor-General of Korea is placed at the head of the Government of Korea. (2). He is chosen directly by the Emperor and is an admiral or a general. (3). He is directly responsible to the Emperor for his command and for the defences and forces in Korea. He is also responsible for administrative matters. (4). He is assisted by a staff consisting of two generals or one field officer, and one A.D.C. These officers may belong either to the army or to the navy. They are exclusively under his orders.

Russia.—The school of flying at Sebastopol was officially opened on the 24th November, 1910. It is commanded by a naval captain, and includes 5 instructors, and 12 officers as pupils, of whom 8 are soldiers and 4 sailors.

Turkey.—An Imperial Irade has sanctioned the reorganization of the light cavalry or Hamidieh. The object of this reorganization is to utilize the Kurdu tribes, which are to be organized into 65 regiments of light cavalry. The regiments will be formed of men of the same tribe, and will have a strength of 4 to 6 squadrons, each of 4 troops of 32 to 48 men. Each regiment will be commanded by a lieutenant-colonel of the regular army, assisted by the head of the tribe, a native major. If there are two tribes in any regiment, there will be a native major for each of them. The squadrons will be commanded by captains of the regular army, assisted by one lieutenant of the regular army, and three sub-lieutenants of the tribes. The length of service will be 27 years, from

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18 to 45, the last twelve years will be passed in the redif, or reserve, of which each regiment has a formation. The regiments will be grouped into territorial inspections, each commanded by a colonel or brigadier assisted by three officers.

Rules on the marriage of officers:—Senior captains who have an increase on the ordinary captain's pay are authorized to marry without permission. Officers junior to this rank are not to do so unless they can prove that their own private means, those of their wife, or the allowance made to them by her parents are equal to the difference between their pay and that of the senior captains authorized to marry.

A. H. Scott.

Rivista di Artiglieria e Genio.

January, 1911.

La France Militaire of the 9th January, speaks of the good results that have been obtained from the first trial of a third dirigible, provided with the apparatus for wireless telegraphy, and having the following characteristics:—Length 68 m., with a diameter of 10·50 m., of the non-rigid type. The car, 18 m. in length, is formed with tubes of aluminium. There are two motors each of 75-H.P. made in the factories at Vienna. The envelope is of German pattern, but also constructed in the Vienna workshops.

The dirigible is provided with an arrangement for regulating the altitude, by projecting—by means of a pump—a water ballast towards the prow and the stem of the car. It is stated that this arrangement is imitated from Mod. III., and was provided in the dirigible *Erlesloh* which was destroyed in 1909 near Cologne. The new balloon is housed in the new hangar at Fischamend.

District Schools for Military Aviation.—*La Technique aéronautique* of 15th January states that General Roques has decided upon the formation of district schools for military aviation. Two of these will be established at Douai and Pau, and another will be formed at Biskra. Officers who have applied for this service will be selected by the commandants of the army corps for attendance at these schools.

After a month of instruction, a certificate as pilot will be granted to those who deserve it. From among the officers who gain this certificate a certain number will be appointed as official aviators, and will undergo a second course of instruction terminating with a trial of three aerial voyages of about 100 k.m., one of which will confer a superior brevet with a number of classification. The non-commissioned officers and men will be able to obtain the brevet of military aviator on the same conditions as the officers. The French marine service is also interesting itself in aviation, and it has been decided to construct aerodromes in the vicinity of the great maritime centres.

An aerodrome has been established at Sablettes, near Toulon, for

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experiments with a new apparatus that can alight in water, and the transport *Foudre* is provided with a large platform that will be used for the aviation trials.

February, 1911.

THE TRANSASIATIC RAILWAY FROM THE BALTIC TO THE GREAT OCEAN.—Lieut.-Colonel V. Traniello, Engineers.—The Transiberian railway may be divided generally into three parts: the *western* from Tcheliabinsk to Ob; the *central* from Ob to Irkutsk; and the *eastern* from Irkutsk to Vladivostok.

This last part, owing to modifications, has given place to the following sections:—Circumbaikaliana, Transbaikaliana, the Eastern Chinese and Transmanchuriana, and the extreme Russian section, or railway of Ussuri.

The western Transiberian railway—1,417 kilometres—follows along almost the whole of its course the 54th parallel, grazing the northern border of the Kirghiz steppe. It runs across a slightly undulating plain upon which are scattered forests composed chiefly of small birches. The soil is sedimentary and porous, black earth, and of recent formation.

The region is poor in minerals, and the stones and lime used on the railway works had to be transported from a distance. The wood was procured from enormous distances, and for its transport roads had to be made and large workshops built, the principal ones being on the banks of the river Irtish. Great difficulties were met with in procuring the stones and bricks. The stones for the bridge at Omsk had to be brought from a distance of 1,000 k.m.

The water of the lakes was quite un-usable owing to saltness. The Transiberian railway crosses four great rivers, the Tobol, the Isciur, the Irtish, and the Ob. It occupies an area of land of 16,770 hectares.

In the construction of this section, it was decided to abandon the plan of crossing the great rivers by ferry boats, and bridges were constructed; the four most notable metal bridges being built across the rivers mentioned above. The Tobol bridge is 469 m. in length with six spans, the four central ones being constructed with parabolic girders and the two end spans with rectilineal girders.

The Isciur bridge is 640 m. in length, with eight spans of which the six central ones are bridged with semiparabolic girders, and the end spans with rectilineal beams. The shoulders of the bridge are constructed of granite from Tcheliabinsk, laid in cement.

The Ob bridge, naturally the longest, is about 800 m.; it has nine spans, the seven central ones being on the cantilever principle. The piers are built on caissons sunk to a depth of from 1·73 m. to 7·25 m. below the lowest level of the water.

It is remarkable in Transiberia that the principal stations are the old fortresses erected during the successive phases of the gradual occupation of Siberia, and which have been transformed into villages and cities. Among these are Pietropavlosk, Omsk, etc. Omsk was constructed in 1765 with five bastions. It is of great strategical importance, being the crossing point of the road from Renburg and from Tobolsk, and was

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constructed by the Cossack general Springo. The scarcity of manual labour greatly increased the difficulties, an immense number of workmen being required. In 1895 the number amounted to 29,000, a great part of whom came from European Russia, although there was also a large proportion of exiles who came from the more distant centres. It is easier to imagine than to give the details of the enormous amount of provisions that had to be transported along an inhospitable and only partly known region.

The cost of the central Transiberian line was 298 millions of Italian lire or about 162,500 lire or £6,480 per k.m. The works were under the direction of the Engineer Mégéuinos. Commenced in 1893, the line was open between Ob and the station of Krasnoiarsk in January, 1898, and from this station to Irkutsk in January, 1899. In 1900 the two sections—western and central—were united into one.

In 1896, the year of the inauguration of the western section, 106,000 passengers, 169,000 emigrants, and 160,000 tons of merchandise were carried, and in 1898 this list increased respectively to 380,000, 195,000, and 480,000 tons of goods. And these amounts went on increasing, notwithstanding that the railway had not reached a port on the ocean. In 1902, between Tcheliabinsk and Strietensk, the number of passengers was 1,400,000. Between 1896 and 1898 it was found urgently necessary to construct 31 new bridges and to add to the rolling stock 30 locomotives and 600 wagons.

Omsk has lost none of its importance, and about the middle of the XIXth century was one of the best fortified places in Siberia. To-day it is one of the principal places of administration, commercially and politically, and a first-class military command; but the old classical fortress only remains as an archeological monument.

The works of the western Transiberian railway directed by the Engineer Michaelovsky, were commenced on the 19th July, 1892, and the whole was opened in October, 1896. The total cost of construction amounted to 46,125,000 roubles.

The *Central Transiberian line*—1,834 k.m.—from 55° parallel (Ob) runs to Marinsk, then following the 56° parallel to Kiansk; here it turns to the south-east and runs in a direction 51° 15′ to Irkutsk on the left bank of the Angara. At Crasnoiarsk it crosses the Fienissei by a bridge of 927 m. long with six metal arches, each 145 m., built on piers of granite with caissons. From Marinsk it follows the great Siberian postal line which it leaves near Kainsk.

These lines pass through immense forests, intersected at great distances by meadows, and occasionally by cultivated fields. The ground is rich with water courses, and is woody and mountainous, especially towards the east where the lines meet the Altaiche and Saianiche Mountains. In consequence, this section (differing from the western one) required enormous excavations averaging 19,000 cubic metres per k.m. with a maximum of 180,000 per k.m. The work was carried out under very difficult conditions, the thermometer in winter showing 50° centigrade below zero.

E. T. Thackeray.

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L'ARMÉE RUSSE AU FEU PENDANT LA GUERRE DE 1904—1905. Traduit de l'Allemand par M. Raoul Marsollet, Capitaine de réserve du Service d'État-Major. 6 francs. R. Chapelot et Cie., 30, Rue et Passage Dauphine, Paris.

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THE OUTLINES OF MILITARY GEOGRAPHY. By Colonel A. C. MacDonnell, R.E. Vol. I. Text. Vol. II. Maps. 12s. 6d. Hugh Rees, Ltd., 119, Pall Mall, S.W.

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SCRITTI EDITI E INEDITI DEL GENERALE GIOVANNI CAVALLI RACCOLTE E PUBBLICATI PER ORDINE DEL MINISTERO DELLA GUERRA. 4 vols. Stamperia Reale Della Ditta, G. B. Paravia, E.C. Torino.

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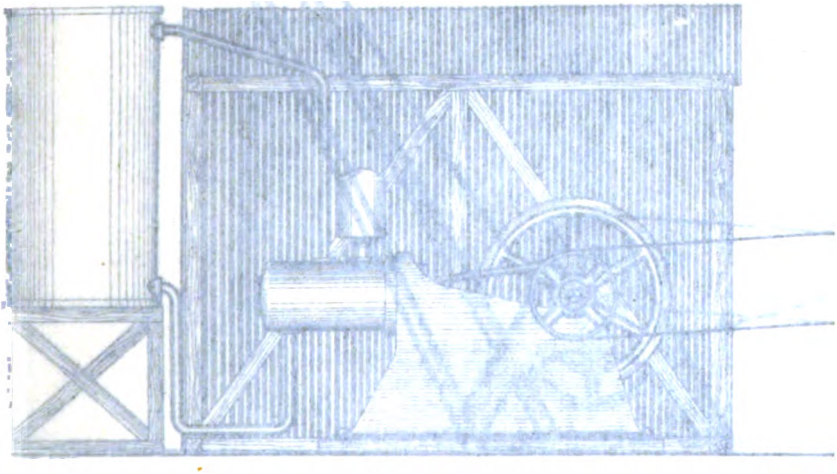

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THE ROYAL ENGINEERS JOURNAL.

Vol. XIV. No. 2. AUGUST, 1911.

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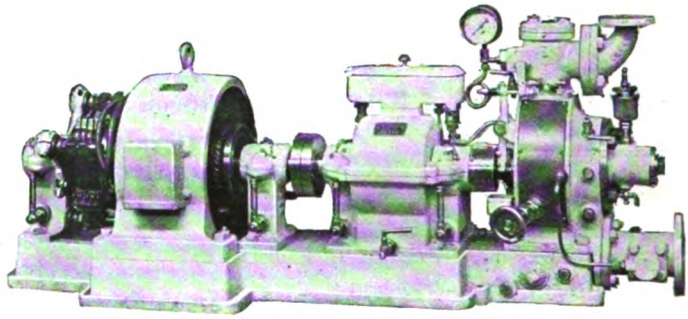

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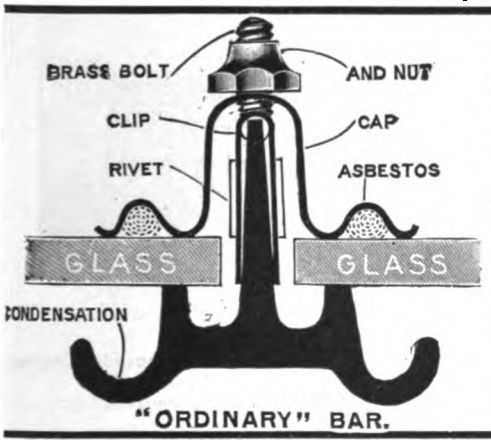

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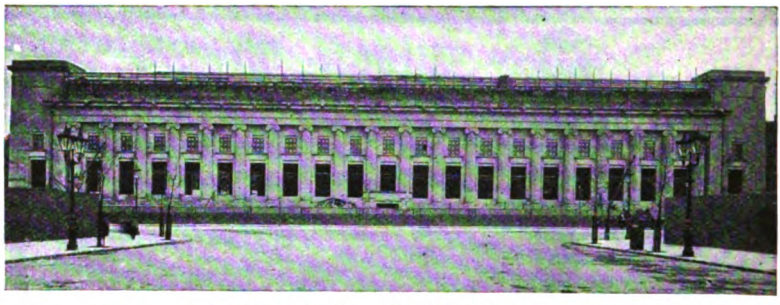

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SOME RECENT TENDENCIES IN FIELD ENGINEERING.

By Capt. E. E. B. Holt Wilson, d.s.o., R.E.

(Lecture delivered at the School of Military Engineering, Chatham, on 16th March, 1911).

Typical Tactics for Resistance.

On active service there arrives a moment when theories and text-books fade into the background, and the young field engineer finds himself face to face with the execution, and not the mensuration, of field defence works. The value of good organization and training, sound strategy, capable commanders, efficient troops, and the lessons of military history, have already found definite expression in the instructions given to him by his immediate superior, and the field engineer is in point of hard fact now required to deliver the finished article, ready for use, and situated on ground unlike any of the favourable examples he has previously encountered in print.

It is chiefly in matters of detail, especially in the correct variation of the normal to suit the tactical occasion, that the officer of field engineers is able to show that he intends his side to beat the enemy, not merely to baffle him.

The particular tendencies of field engineering which it is proposed to examine now are those of the technical design of certain of these details of fieldworks, more especially as disclosed in the recent publications of foreign countries.

All armies have normal types for fieldworks. They are based upon the tactics considered most likely to lead to victory over the most probable opponents; and in Continental manuals of engineering the types are planned almost entirely for use in the particular variation of the offensive-defensive which it is expected will be employed against highly trained civilized troops—the situation, for instance, of our Territorial Force employed for home defence.

We have become so accustomed to acknowledge that the correct tactical application of fieldworks is everything and the details nothing, that we are in danger of leaving it at that, and of trusting entirely to such flashes of Napoleonic genius in matters of detail on the part of all ranks, as we already demand from the higher commanders upon the momentous question of when to launch their general reserve beyond recall. We must remember however that tactics themselves

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are in part only the methods employed to get the most effective shooting out of a given force, and that the shooting itself is the thing that matters. As the principal function of all field engineering—properly applied—is also to get the most effective shooting from the smallest possible given team, we are on clear ground at once and can proceed to details.

The days have now passed when entrenchments were issued by the yard run conformable to sealed pattern,—in peace time only too frequently as tortuous exercises in mensuration at paper examinations, and in war as "some fad of the engineers" to be carried out under protest by the unwilling troops. Redoubts, even, are no longer planned at the office table and served out in stock sizes, like hats, to be crammed somehow on to the crown of hills many of which have nasty habits, in the Quartermaster's language, of turning out to be "specials." But though we beware of stock type-designs and stock systems, it does not mean that we go hatless because the sealed pattern article does not fit our head.

The spirit of the offensive rightly permeates all manuals of field engineering to-day, and good normal details should accordingly possess inherent adaptability to the purpose of sound offensive tactics. It is therefore difficult to choose a normal tactical peg on which to hang samples of fieldworks; for current tactical conceptions of their use as an aid to good shooting have such a wide range. We have a good ideal in the Japanese idea of placing rows of dummy parapets on a false position, holding them with just enough men to make a sufficient show of resistance to cause the enemy to deploy for attack, and then hurling on the flank of the attack the whole nation in arms—hitherto concealed round the corner! But perhaps this might be a little too advanced for our present purpose.

STRONGHOLDS OF DISPERSED ELEMENTS.

Leaving the main striking forces out of the picture it will perhaps be safer to assume that the defensive share of the fighting is to be done by a relatively small number of troops *placed in charge of*, not "posted for the defence of," a zone of resistance, which, starting from the smallest beginnings, develops its strength from hour to hour to meet the particular stresses to which it is being subjected. The backbone of such a defence may consist in some of the troops judiciously posted in a chain of mobile garrisons, of strength proportionate to the estimated difficulty of their tasks, and within co-operative distance of each other. Their business is not to repulse attacks but to encourage them, and to be a terror to the neighbourhood; to be a hornet's nest when stirred with a stick, and yet able to roll themselves up into the prickliest ball of a hedgehog that ever baffled a pack of terriers. They should ensure that the hostile scouts

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do not report that the enemy are entrenched at such and such points but that "the country is infested with the enemy."

The underlying principle is that every man and gun should be continuously employed so as to immobilize the largest possible number of the enemy, keep them out of mischief elsewhere, get their teeth into them, and at the same time make it impossible for them either to withdraw, or even to maintain their ground, without a steady drain upon their reserves.

The depth of such a zone of resistance should be sufficient to provide inducements for the enemy to develop an irregular and broken frontage, deficient in lateral cohesion, tending to present local flanks vulnerable to local attack by local mobile reserves, and difficult of support by artillery. In brief, to catch flies in detail by enticing them to walk across a wide strip of sticky paper instead of rebuffing them with a wire gauze screen, without catching them.

In order to produce the necessary distortion of the attack; to afford foothold for these garrisons in times of extreme stress; and to act as pivots of manœuvre within the zone of resistance, the consensus of foreign opinion points to the selection and fortification—probably in the form of miniature field fortresses with definite garrisons finding their own local reserves for offensive action—of a certain number of small areas which are likely to become or to contain points of possible future tactical value to the enemy. We cannot as a rule label them "tactical points" by virtue of any topographical consideration alone, for "tactical point" is not a geographical expression, but one compounded of time *and* place—which may be defined crudely as "the piece of ground the enemy would like *next*." Fighting a zone of resistance on chance ground in the open field bears to a strategically chosen and deliberately fortified fortress area much the same relationship that a point-to-point race across unflagged country bears to flat racing between the rails, and it requires a constant succession of bold and rapid decisions and ceaseless activity with the spade. Granted that, for our present purposes the zone of resistance will include the provision of some self-contained entrenched groups, strongholds, or redoubts, we will examine their probable disposition and design.

The first and principal lesson taught us as field engineers by the Russians in Manchuria is the failure in defence of a linear disposition of fire trenches closely supported by rear lines of trenches or redoubts which are not fully engaged until a portion of the original front line has fallen. The centre of gravity of the defence has moved forward from its old position on the lines of strong closed supporting works in rear right up to the very foremost trenches, and has taken the strong works with it. "Foremost" is not here used in a linear sense, but in the sense of having the pick of the early firing points, a step-by-step abandonment of which is not contemplated.

Such a stronghold or group then must fulfil two distinct purposes:

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to be the headquarters of an offensive hornet's nest by day, and the prickly hedgehog during fog, darkness, reduced garrison, or the heavy rush ; and all the time it must take a steady toll of the enemy without letting him attain his object, namely to open secure communications through the zone of resistance. Any attempt to rely upon one general disposition of troops to deal with both sets of conditions, especially that suited for hedgehog tactics alone, has usually led to failure. For dealing with the enemy by day we must have, in addition to artillery, numerous alternative, invisible shooting pits and small but deep trenches, to hold from 4 to 50 rifles each, well disposed to get the pick of the shooting, with plenty of small bolt-holes and shelters, and all in covered communication with each other and with supports and local reserves.

For passive resistance during the close seasons of darkness we must arrange that the enemy, before he can overrun the group, *must* pass over our section of near foreground which has been marked out in a series of well-fenced death-alleys, every foot of which can be brought under a deadly enfilade fire from firing points which are manned for this purpose alone and if possible entirely screened from the direct fire of the enemy. Such firing points are often designated as "stabbing" trenches or "stabbing" batteries.

The measures outlined above form however but the second of the important activities of the garrisons of a zone of resistance. They have been selected as being more closely associated with the heavy work of the field engineer than are the primary services of protection by reconnaissance, which provide the forewarning without which forearming is futile.

An advanced screen or false front forms a connecting link between the measures of protection by reconnaissance and of protection by active resistance. Its preparation may often call for greater skill in treatment by the engineer than the main zone of resistance itself. Great importance is attached in most continental armies to the use of an entrenched false front not only as a means of obtaining indications of the enemy's intentions and dispositions, but as a means of gauging his powers and methods of attack, and of inspecting his armoury generally, in sufficient time to arrange a suitable treatment for him in the main zone of resistance. If his artillery is to be brought under review, guns must form part of the advanced screen also.

But although the engineer, thinking perhaps of the unreadiness of his freshly planted "concealments" and unfinished communications in the main zone, may be tempted to put such good work into a false front that, with modern weapons, this front may unexpectedly hold its own with ease as a barrier screen for a considerable period, such success may not always further the intentions of the commander to get his teeth into the enemy and worry him in the main arena. Such

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an unintentionally severe check to his advance may end in so sudden a change of his plans that not only will the Intelligence Department of the defenders be hard put to it to overtake his new movement, but their engineers may scarcely have time to dig and roof the next series of fighting pits, still less to complete the gardening of the peaceful landscape with its steel wire undergrowth.

If such a screen is formed in front of an entrenched zone of limited frontage it appears to be advisable to keep its main positions well out to either flank. This may cause a greater and more premature dispersion of the enemy in deployment than the original frontage of the main zone would have done, and will increase his circuit for the turning movement which is awaited in all positions of limited frontage ; while the withdrawal of the screens will leave them still playing the part of echelon supports to resist the envelopment of the main zone round which they pivot, and at the same time decoying the enemy into well "treacled" ground.

Redoubts.

It should now be easy to realize why the very word "redoubt" has almost acquired a guilty sound of defeat in the soldier's ear. In its hitherto accepted form and meaning it has been associated almost exclusively with the form of resistance which may be described as the "rolled-up hedgehog and hope for the best" policy—the last resort of the half-beaten soldier. The principal defects of the small fort or redoubt which stood alone, excluding the tactical aspects of its employment, were one or more of the following :—relatively short and formal frontage of continuous fire parapet, still shorter flanks, often traced from arbitrary or even geometrical considerations to deliver a "defensive" flanking fire regardless alike of probabilities and of the demands of adjacent works for particular lines of supporting cross-fire. It as a rule occupied one small topographical feature, and that imperfectly, and often added to this vice that crowning crime of visibility from afar which has been said to form one of the chief safeguards of some of our defended ports against oversea invasion—because the cry of "Look at their forts" might send a battalion of the enemy with such a rush over to one side of the vessel carrying it that it would capsize in deep water. The small formal redoubt can perhaps be seen in its most pernicious form in some of our earlier designs for that ill-mated partnership—a battery for heavy guns and a flank and gorge parapet of formal trace for so-called "musketry defence," the whole surrounded by an unflanked obstacle of oval trace, just as it came out of the standard-plan cupboard. Surely the zenith of tactical confusion in the application of fortification to war !

The Russians realized much of the foregoing in Manchuria when it was too late to change their tactics in passive resistance ; for to-day a

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change of method in the application of field fortification is no longer merely a change of trace or profile, but affects the fundamental training of the troops who are to employ this weapon. The Russians tried, in their field entrenchments, to put their formal redoubts right by adding wing or whisker trenches to increase the frontal fire, but were too late in realizing that the closed works themselves should have been right up in the front fighting line, and of tactical, not formal, trace.

It was not until the close fighting had set in at Port Arthur itself that they endeavoured in costly haste to relegate their monumental permanent forts to their only possible *rôle* as "keeps" to a series of modern entrenched groups, and ploughed the rocky foreground with numberless fire trenches in the attempt to meet the advances of the enemy on even, if not superior, terms. But the ardour of the enemy's attack and the rocky soil were against them, and their groups never developed sufficient strength to perform their task effectively, either in mutual fire support, intercommunication with the main arteries, or in dispersion and multiplication of targets to dilute the enemy's heavy fire.

What can be done in the way of resistance, even by an indifferently entrenched but well-fought group-stronghold, is strikingly exemplified by the case of the twin redoubt group on the 210-203 Mètre Ridge. Here a garrison of 1,500 Russians, renewed until they had suffered 3,000 casualties, inflicted a loss of upwards of 14,000 men upon their still braver attackers before the group fell.

There are three typical positions for the employment of invisible redoubts in a group stronghold in the first line, of the type under consideration. Not being limited as a rule to one topographical bump on the ground, the extent of frontage taken up by such a group can often be lengthened and can be given the pick of the firing points for frontal fire until favourable ground is found to develop a really effective flanking fire across the adjacent groups. All flanks are a source of anxiety and here is one typical position for the use of redoubts—redoubts with their main lines of fire devoted to the control of the intervals, and their own flanks and gorge traced for home use in the passive defence of their group in times of stress. The second typical position for a redoubt within a group is such as to stiffen a salient, if any, in the main front of the group—but here there is a divergence of opinion—the Germans put a redoubt in the forefront, but the French prefer the third typical position namely behind the skyline as seen by the hostile artillery.

The merits of the second and third positions are questions which we have not time to discuss at present and are after all dependent upon local circumstances. Which redoubt should be selected for early strong treatment to form the key or keep of the group depends more upon the enemy's tactical facilities in attack than upon local

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topography, though the importance of developing the full *offensive* powers of all works from the first has already been alluded to.

The general treatment of the intervals between such groups appears to be the provision of a chain of selected firing points well echeloned back in a concave festoon in plan, entrenched and concealed, but only lightly picketed with troops; ready to receive fresh troops if called upon to check a serious attempt to punch a hole through an interval; as a screen in front of lateral communications and of batteries posted in support of the groups, and for controlling ground dead to the fire of the groups.

We will now examine a few types of fieldworks which may help to illustrate some of these recent tendencies in further detail.

A Sketch of a Field Stronghold or Group, planned for Field Defences and Mobile Artillery (*Fig.* 1, *Plate* I.).—There are 12 alternative concealed pits for direct fire guns, of which four are for emergency use in the defence of the salient. Ten alternative emplacements for field howitzers, of which two (marked H 6) are set back to develop fire upon dead ground in the S.W., on the 500 yards rifle zone, and four (H 2 and H 5) for the special assistance of adjacent strongholds. Redoubts at the flanks. A second tier of direct fire as a salient keep. A wire obstacle enfiladed by machine guns and rifle fire. Echelon support is derived from other mobile guns and howitzers, and an additional obstacle for artillery enfilade is provided on the salient spur to the west. Liberal communications are provided throughout the group, and numerous small shelters in the firing line, redoubts, and reverse slope communications, each to hold about 5 to 10 men. Two field emplacements are provided outside for mobile electric lights, with the usual artillery and infantry fire control and observing stations. A guard fence is shown to assist in the control of the intervals at night, and to defer a near approach to the main obstacle. The group occupies about 150 acres of ground, an area about equal to that of the "Feste Kaiserin," one of the satellite strongholds of the Fortress of Metz.

**A Permanent Stronghold or Group* (*Austrian*) (*Fig.* 2, *Plate* I.).—The backbone consists of three pairs of armoured Q.F. guns for direct fire, and four long range direct fire armoured guns on the highest point. The fire position for infantry is in the form of a curtain trench between the Q.F. guns, which are at the salients. At the gorge are two masonry shell-proof shelters which provide reverse musketry fire, and gorge stabbing batteries for flanking the intervals. The obstacle, which is in an open carefully graded ditch, is enfiladed from sunken flanking galleries, and by the gorge shelters.

A Simple Group, or Extended Redoubt, Field Entrenchment (*Austrian*) (*Fig.* 3, *Plate* I.).—This is an example of a redoubt taken to

* From *Permanent Fortification for the Imperial Military Training Establishments, etc.*, by M. R. von Brunner, Major, Austrian Engineer Staff, 1909.

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pieces and distributed to the best advantage for fire effect. There is continuous communication but not continuous fire trench. Six shell-proof shelters in masonry would classify it as a "provisional" work. A "keep" is formed at the central forward salient, marked 6. The wire obstacle is more or less well flanked.

German Field Redoubt for One War Company (220 *men*) (*Fig.* 4, *Plate* I.).—Plain oval trace, 50 mètres front to rear. Unflanked obstacle, and outlying sentry pits. Forty-four shelters for five men each provide shelter for all the garrison. The latrine and dressing station are on the forward slope, at 5 and 3, and the headquarter telephone shelter on the reverse slope at 4.

An Example of Fire Trenches refusing a Flank in Echelon (*Fig.* 5, *Plate* I.).—Echelon support is considered better than "turning back" the flanks whenever possible, as it increases the circuit of the necessary outflanking movement. The unit trenches are similar in principle to the example in the *Manual of Field Engineering*, 1911, *Plate* XVI., and portions of the support trenches, under cover from the front, are prepared to act as stabbing trenches for flank fire only. One machine gun is shown flanking the forward slopes of an outlying spur, and one in a stabbing emplacement, to sweep the crest and reverse of the spur. A temporary end is formed with a closed work and stabbing battery, and is supported conventionally by mobile reserves of three arms, and covered by heavy artillery still further back, and not shown on the sketch.

[*Six other examples were also demonstrated*].

PROTECTIVE PROFILES.

Profiles of fire trenches are not illustrated in textbooks as a prescription for effective shooting, but as a normal and economical provision for protection, concealment, and communication under certain average conditions of time, labour, soil, site, and field of fire which are seldom all found in conjunction; and it is extremely unsound to lay down a given profile to be adhered to, even throughout the length of one small trench. To lay down or report in a paper scheme that a whole position would be entrenched, and shelters made to a given profile, (not unknown in the past) would show a disregard for death and local peculiarities which might be magnificent, but certainly not war. A fundamental rule in defence must always be that *each* rifleman is entrenched to the best advantage to give a good account for every cartridge he fires: and whilst inside his lair must not get killed except by accident. Beyond that it is of little interest to know how many cubic feet of earth he disturbs for the purpose; though it is often of great interest to know that it will average so many hours *per rifle* to arrive at the required result. Even this can only be a wild guess before at least a portion of the given sites

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have been actually dealt with under the war conditions prevailing at the moment. The differences of time from the normal caused by war factors are more often in days and weeks than in smaller units of time. A sound rule in such estimates of time is to add 24 hours (to the calculated answer) for the "King's enemies," earthquakes, rain, etc. Remember also that "easy soil" means more excavation, more revetment, more return-filling, and generally *more time* to arrive at a given profile or degree of protection than in ground firm but not rocky.

It may not be without interest to glance at some typical normal profiles of fire trenches from foreign armies.

Normal Profiles for Fire Trenches (*Fig.* 6, *Plate* II.) *as used by France, Russia, Germany, Japan, and Great Britain.*—Fire standing is normal for all. The arbitrary effect of local units of measurement is evident in the figures selected for describing a suitable average height over which to fire standing on level ground. Russians fire over 4′.8″ (2 arshin); France and Germany, 4′.7$\frac{1}{8}$″ (1·40 mètres); Great Britain, 4′.6″ (4$\frac{1}{2}$′); Japan, 4′.3$\frac{1}{5}$″ (1·30 metres).

The height (1·30 mètres) for normal "fire standing" adopted by the Japanese is that considered suitable for a man 1·54 mètres in height (5′.0·63″). Taking this proportion (five-sixths of the man's height) we find that 4′.6″ corresponds to a height of 5′.5″ nearly, and that a Guardsman of 6′.0″ should fire over 5′.0″ on level ground.

Four types of profile are illustrated, and the average cross sectional area in square feet is given above each type. The average time to *excavate only* two paces of the average profile of each type, at British normal rates of work, is as follows:—*Type 1, without parapet,* 3$\frac{1}{2}$ hours; *type 2, with parapet,* 1$\frac{1}{2}$ hours; *type 3, deepened,* 5 hours; *type 4, kneeling,* 50 minutes. The designers however claim a higher speed in their textbooks.

Points of interest are that Russia and Japan have adopted a *normal* parapet command of 1′.9″ and 1′.8″, as the result of a stern experience of average values, and have cut the width of their revetted firing step down to 1′.2″ and 1′.4″ to get the utmost value from the cover of the interior slope. Many other points of comparison could be drawn and discussed. On the whole our types appear to be on the wide side of the average (and would be wider still in soft ground) and unduly exposed to plunging fire on account of the great width of elbow rest adopted and the low height (4′.6″) fired over compared to the other European armies of equal, and in some cases lower, average stature.

The Russians and French leave the question of elbow rest for local adjustment by the rifleman. The former however provide a cartridge berm, of the width of the hand, at ground level, and invariably shoot over fire cover with the *left hand on the butt* of the rifle: thereby deriving the last ounce of cover and steadiness from the parapet.

In "*type 3*," with a passage trench in rear of the firer, the British normal type shows the greatest total vertical depth of cover (6′.6″);

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which is attained by the drop of 2'.0" from the firing step; as compared with France and Japan 1'.4", Germany 1'.8", and Russia 1'.9". The Russian type also shows a parados as a normal provision, partly in order to reduce the area of parapet to be concealed in front, and partly for reasons indicated presently.

One of the duties of a normal profile is to suggest ideals, and the representation of a vertical interior slope by France and Great Britain serves as a reminder of the importance of reducing to a minimum the horizontal distance between the foot of the interior slope and the firing crest above it.

ENTRENCHING UNDER FIRE AND IN THE ATTACK.

All manuals deal cautiously with this subject for fear of training their infantry to entrench every attack to a standstill.

The French say "a trench dug during the attack must never become the grave of the offensive spirit."

It is rather a pity that the subject is somewhat shirked, as we all know very well that it will probably only be by means of the spade that any modern troops will be able to make good their advance upon troops already entrenched, or even behind better natural cover. The subject is however almost entirely a tactical one and in technical details falls under an introduction to the subject of siege works.

The Russians have shown a distinct tendency recently in favour of the use of sandbags in the attack as a preferable alternative to grubbing with the entrenching implement. A suitable bag is said to measure about 20" × 14", with 40 lbs. of gravel. Coloured grey-green it is said that a man is invisible behind it at 1,100 yards in the open, and that even at 400 yards the target is extremely difficult to pick up. It is also claimed that as it can provide bullet-proof cover the men much prefer the labour of dragging it along 30 or 40 yards at a time to the unsatisfactory process of frequently grubbing in the ground only to provide a very visible and non-bullet-proof screen,—for bullet-proof cover is as a rule out of the question in this class of work. There is also considered to be less danger of the attack entrenching itself to a standstill.

A German comment on this principle claims that the occasions for favourable use would be exceptional, and that it would diminish the men's activity and cripple the offensive spirit—remarks which would be equally applicable to the provision of any entrenching implement at all for use in the attack, and which appear to point more to an optimistic estimate of the bravery of the soldier than to the recent experience of the stern realities of war which underlie the Russian experiments.

[*Examples of the methods adopted by various armies to entrench under fire were also demonstrated*].

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Protection in the Firing Line from Enfilade and Reverse Fire.

The full importance of effective traversing from oblique, enfilade, and reverse fire is not as a rule properly appreciated except when under fire. One has only to study the development of details as a war progresses to notice the general tendency towards placing every rifleman under a lid and in a safe tub of his own, for shooting from; and in a still safer bolt-hole near by for protection when he is being "over shot at." Whether it is that in peace we do not realize the full range of modern weapons—for the German rifle kills at 4,400 yards (2½ miles), or that we are over-sensitive in admitting the fact that little mistakes such as "shorts" from supporting artillery, or a terrific outburst of rifle fire from over-excited supports are constant occurrences in war, and must be insured against. The fact remains that when trigger-snatching begins in earnest streams of metal will and do arrive from absolutely untraceable sources.

From starting without any traverses to speak of the Russians finished up in most places with a recess for every rifleman, and heavier "passage traverses" from 8 to 15 yards apart according to the degree of obvious exposure. Back cover is provided always. This may be raised high enough to provide a background if necessary, but no traverse is ever allowed to show above the general level of the parapet, and, especially on a forward slope, every traverse is made to fall to the rear at a steeper slope than the line of sight from the enemy's gun positions.

We find also in the final Japanese lines north of Tiehling the men were recessed in twos and threes, and similar traverses were used.

A moral value of many small traverses is that they often save men the knowledge of what has happened in the next compartment. Density of fire line has ceased to affect the question seriously, since the Russians tell us that *trained* riflemen well entrenched from 5 to 8′ apart can deal with the worst situations by day or night, and it can usually be arranged to develop an emergency shoulder-to-shoulder line, if desired, to fire over any parados or head cover at night.

[*Five examples of typically traversed trenches were demonstrated*].

Protection from Plunging Fire.

About the value of good head and overhead cover as an ideal there are no two opinions, and Lieut.-Colonel von Swartz, of the Russian Engineers, writing while the lessons of Manchuria were still deeply bitten into his Sapper conscience, says :—

"The designs of the days of infantry parapets without head cover for the rifleman must now be put away among the curiosities of

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ancient history." The Japanese, Russians, and Germans all agree that overhead shelter from splinters and bullets *must* be provided somehow *actually in the firing line.*

It may be taken as an axiom that a rifleman detected firing from behind *visible* cover is at an actual disadvantage as compared with an undetected opponent who is making intelligent use of natural ground cover; and the former may as well, if he has the time and material, roof himself in straight away.

But before any form of head cover is undertaken as a *precaution in advance* the following question has to be answered in the affirmative :—"Shall we have the time and the means to render our *head-cover* indistinguishable from our background at the distance at which it may have to face the enemy's artillery?" If the answer is no, or even doubtful, it would be wiser to dismiss the idea as tending to weakness rather than strength, and to put the labour into small and numerous shelters *inside the fire trenches*, to deepen cover generally, and to make sure of good communications and concealment.

Once we have definitely been found out and ranged by both gun and rifle, and concealment has failed us, in the absence of alternative concealed cover, our next move is to multiply targets incessantly, and to strengthen our cover regardless of concealment, including if possible the addition of *overhead cover*, and so to dilute the enemy's fire by offering such a bewildering choice of suspicious objects that the smile is once more on our side. Or we may follow this policy from the first, as most other armies do, if we cannot trust to concealment. On the other hand there appears to be no excuse for omitting well-concealed overhead cover in strategic defences deliberately prepared from 24 hours and upwards in advance.

We can now examine some examples of cover in fire trenches.

A Type of Box Loophole suitable for Use with or without a British Service Loophole Plate in Deliberately Concealed Works. To give 60° *arc of Traverse* (*Fig.* 7, *Plate* II.).—The result of experiments to get a ready-made loophole which can be turned out in numbers, and will probably provide a better shoot than the article hastily built up by the untrained soldier. The plate is not fastened to the box, but slips in between the box and the revetment tray. The screen preserves an unbroken exterior slope to the head cover and avoids the black shadowed tunnel which usually vitiates all attempts at concealment.

Overhead Cover, with Curved Iron Sheets, suitable for a Redoubt (*Fig.* 8, *Plate* II.).—The parados is joined up to the head cover, and acts as a reserve parapet in the event of damage to the light blindage, and as a second tier of fire at night.

An Example of Overhead Cover in Reinforced Concrete (*Fig.* 9, *Plate* II.).—Consists of a 6′ × 6′ gallery with 4′ roofed in. Steel loophole plates to open forwards and up. [*Details of the loopholes were also shown*]. An upper platform provides for overall fire. The

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hollow under this platform provides full length sleeping space. A "shock absorber" of loose boulders is given in front of the interior slope revetment. The soft parados behind is arranged to act as a reserve parapet. The cost of construction is about £9 per rifle. Time, about 10 working days with European facilities. An extension of this design by thickening the floor to 3′ will provide good underground shelter.

Parapet Shelters, German (*Fig.* 10, *Plate* III.).—Shows two shelters, for five men each, between traverses 10 mètres apart. 3′ 3″ head room; 22″ sitting space each man. Wooden flaps are provided extra to guard against splinters and rain. No interruption to the firing line. No traverses showing above the parapet, and an easy curve round their ends. Parapet shelters of this nature figured prominently in the defences of Kimberley.*

Parapet Shelters, Russian (*Fig.* 11, *Plate* III.).—

1. Direct support from firing step.
2. Shelter at the lower level, and stronger.

Interruption of banquette is not necessary. Men can climb over the earth step, if left, as in the German type (*Fig.* 10).

Larger Shelters, German (*Fig.* 12, *Plate* III.).—For 20 men each. The chief feature of interest is the use of curved steel sheets, of special make, 1 mètre wide, as an article of store and bolted together at the crown, in pairs. Suitable for permanent centreing to concrete also. Very rapidly used as compared with timber, and more portable.

Sketches for a Dressing Station for Wounded (*Fig.* 13, *Plate* III.).—Requirements of dressing station are 2′ clear space all round a table 6′.6″ × 2′.6″. A shelf and a seat.

Shelters for supports should enable men to sleep lying down. Seats, if provided, must not encroach on the minimum floor space or they will probably be demolished after the first night. Each shelter should be numbered, and in direct communication with firing points similarly numbered. The roof is often provided with a "burster layer" of boulders, or better, inclined rails to induce ricochet. The size of shelters is nearly always controlled by the materials available for roofing, and cannot be standardized, but the rule is "*many and small.*" As regards actual resistance to shell fire the Japanese consider 4′ of earth, with a burster layer of boulders, a fair protection against single field gun shells, and 6′ or 7′ against single light field howitzer shells. The Russian figures run from 4′.8″ to 7′, and the German from 3′.3″ to 13′, while against heavier howitzers (6″ and upwards) a thickness of 16 to 20′ of earth or 9′ of concrete may be necessary.

[*Twenty further examples of cover were demonstrated*].

* *R.E. Professional Papers*, 1900.

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COMMUNICATION EARTHWORKS.

A better realization of the paramount importance of mobility in defence, the occupation of wide frontages, and the increased accuracy of artillery fire, have sent up the mileage of communication trenches to a length which may well appal the engineer. Not only safe paths for foot traffic, but sunken ways for pack transport, and sunken roads for wheeled artillery were provided on a prodigious scale by both sides in Manchuria.

Although such communications cannot all be developed at once the safest routes can and must be selected and marked out immediately, so that they can be followed by night or day. Cover from view is the keynote. No one will waste shot upon communications if they do not know when they are in use; but on forward slopes, such as between supports and firing line, communications must either be absolutely concealed or omitted altogether if the firing points are not to be betrayed.

For foot traffic the Russians say "keep the width down to the minimum, about 2′ 4″ at the bottom, and make passing places of double width every dozen paces, with occasional recess refuges if there is much traffic. Throw all the earth on the exposed side, and only divide it if doubtful. Go on gradually deepening up to 7′ as long as the trenches are in use."

In Japan and America experiments in the rapid preparation of long lengths of trench for easy excavation have recently been made by detonating light charges of explosive along the trace.

In America charges of 8 oz. of dynamite dropped into holes jumped about 2′ apart and 2′ deep were fired simultaneously over a considerable length by the shock of detonation of a single charge towards the centre. These loosened the ground to a depth of some 4′.

In Japan a continuous charge of 11 oz. per foot run laid on the surface of the ground rendered shovelling easy for some 3′ below ground.

The immense importance of good covered communications has hitherto been somewhat overshadowed by the supposed paramount importance of early preparation of the fire positions themselves. In peace practices it is quite the exception to find that the necessary communications within an entrenched zone have even been marked out by the time the fire positions are completed; whereas the process should be exactly reversed. The fire trenches are a matter of hours, and paradox though it may be, the later they are sited and made the more use they are likely to be, whereas communications take weeks to develop sufficiently to ensure that the defenders may compensate for their lack of numbers by their powers of rapid concentration for the production of a superiority of fire at any given point.

Take a visionary example. A stronghold intersected by tube-

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tunnel railways could be provided by this one means with bombproof shelter, countermine galleries, stairs to the surface close in rear of every good rifle fire position, sidings to run out the truck-mounted guns to every good artillery position, lifts at every point suitable for electric searchlights, and safe signal services, all at a cost less than that of a chain of massive forts and fixed armoured batteries. Yet without a single rifle pit it might well be considered likely to prove a harder nut to crack *in the hands of good troops* than any fortress recorded in military history.

[*Four illustrations of communications were demonstrated*].

Obstacles.

Obstacles, like other fieldworks, are good servants to the rifleman only when they enable him to increase his bag. The German axiom, that the most effective obstacle is the fire of the defender, is only another way of saying that no one is going to try to pass a good obstacle by daylight as long as every foot of it is under effective fire; for the Germans make immensely strong birdcage wire obstacles themselves.

To ensure the repulse of a heavy night attack not only is a good obstacle essential, especially on short range European battlefields, but it must be, as far as possible, under easy *enfilade* fire from points definitely prepared and screened from direct fire. Radial fire is weaker than ever in the dark, and as a mere passive obstruction, not controlled by fire, an obstacle soon melts away. The tendency now is to realize that the night obstacle problem must be divorced from the daylight fire problem, and that it is usually unsound to make the trace of obstacles slavishly conform to the dispositions for general fire effect. In dealing with obstacles and close fighting we are in many points carried back in a moment to the conditions prevailing in the days of Vauban. This is not new, for General Brialmont exemplified it many years ago in his triangular ditch round a fort of oval fire trace. We have now passed beyond the stage of the oval fort in the shooting department and the obstacle question becomes more and more a detached problem. Although it takes many hours to complete an effective obstacle, a very short time will suffice to get a few strands of wire up throughout the trace, and this should be the first move. The finished obstacle also need not be of equal density throughout, but should increase in passive strength in proportion to the difficulty of effective fire control, which may be due either to distance or to bad ground. It is usually quicker to "landscape garden" the obstacle itself than to dispose and conceal the earth thrown from a glacis trench in which to sink it. In war we *may* have to use silver-bright barbed wire picked up locally, but it would

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be unpardonable to issue it from store until it had been through the green or khaki paint. The Germans issue special instructions for the daubing with clay of all freshly cut wooden surfaces on the posts of wire obstacles, and advocate concealment by transplanted vegetation.

Most obstacles made in peace time convey the impression that the enemy may try to jump them in marching order. Crawling is the pace and attitude of war, and density of wiring near the ground, and a few cartloads of broken glass, are disappointing to crawlers.

No more suitable article of store for use in the rapid construction of obstacles has appeared in recent years than the expanded metal gabion. A continuous central core of such gabions threaded on two or three uncuttable wire ropes and densely wired at all heights to other gabions spaced out instead of posts, the whole stiffened with a few steel fencing posts as holdfasts, and well strewn with broken bottles lightly earthed over, should afford plenty of promotion for the enemy's sappers.

[*Three illustrations of modern obstacles were demonstrated*].

OBSERVATION AND FIRE CONTROL IN ENTRENCHMENTS.

There is no necessity to emphasize the important part now played in defence by protected look-out and fire control posts. Several examples of infantry observation posts have already appeared in the plans of works shown, and it will have been noted that they are sited quite independently of the firing portions of the works. The generally agreed principles for their disposition are that there should be enough look-out posts to keep the whole field of fire and every possible line of approach under close observation by day. If possible not more than about 45° of arc should be allotted to one observer. The German normal type shows about 40°, the Russian 75°, which appears to be rather too much.

Since the observers *must* remain on duty under artillery fire, storm and tempest, protection and concealment are of paramount importance. They are therefore best well away from visible entrenchments, but must be in communication with the fire control posts both by signal and by covered walk, and if in advance, must be well screened from reverse fire. By night a different set of look-out posts would usually be required if the defences included obstacles, and the men in such posts should be close to any alarm guns or flare lights provided, and able to operate them at will independently from any involuntary operation of them by the enemy.

An officers' fire control post would usually include a look-out pit, with a splinter-proof shelter near by for the telephone, signallers, and orderlies awaiting messages. This look-out pit requires a wide arc

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of view and should include all ground under fire by the men under the officer's command. An ordinary fire loophole is quite unsuitable. A horizontal slit, in steel plate if possible, about 2″ high, 12″ wide and 5′ above the observing step, is usually convenient. A seat should be provided 2′ 1″ below, and an elbow shelf (12″ wide) 1′ 1″ below the sill of the look-out slit for convenience in the use of binoculars.

In the O.C.'s post a megaphone aimed at one or two of the adjacent subordinate fire control posts should be kept fixed and ready for use at night in addition to a loose megaphone on a peg. Rockets and light signals for communicating at night with more distant posts, or with artillery, may be stored in the O.C.'s shelter. The map (ruled in the same squares as that with the artillery) should be oriented, in a good light, but protected from weather. Enlarged sketches of foreground can ignore the relative sizes of the conventional signs and should have the important range features boldly indicated and lettered to read easily *when the reader is facing the feature*, not, as sometimes seen, written upside down from a mechanical sense of homage to "α Ursæ Minoris." In addition to the lists of ranges chalked on the sides of traverses, etc., every range so marked should be actually verified by rifle fire—a precaution often overlooked—and every man should constantly be made to repeat from memory the ranges to his targets, even when a certain number of them are already marked on the ground with their actual range by a number of visible objects corresponding to the number of hundreds of yards in the distance.

[*Illustrations of the use of hyposcopes and fire-control posts were demonstrated*].

Cover for Machine and Field Guns.

Machine Guns.—All the principal armies now fight their machine guns from low tripod or sledge mountings—the latter being favoured by Germany and Russia.

Our "Maxim" and the French "Puteaux" fire over a height of from 14½ to 30″. The German sledge mounting fires from a ramp varying from 4″ to 2′ 4″ below the fire crest (*Fig.* 15, *Plate* IV.), and the Russian variety (*Fig.* 16, *Plate* IV.) fires off a level shelf some 3′ wide and 7″ below the fire crest. The advantages of the shallow sledge mounting working on an inclined ramp which permits of instant withdrawal are obvious.

Cover for the detachments and a protected look-out must be very near and very safe, since the weapon is essentially of the "now or never" variety and the detachments have to keep alert under cover for hours or even days ready for a few seconds' shooting at the warning of the look-out man (*Fig.* 15, *Plate* IV.).

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Stabbing Batteries of Machine or Field Guns (*Fig.* 14, *Plate* IV.) for close range flank fire in the open field are greatly favoured by the Russians, and find a place in all recent designs for permanent works. In the latter they are usually found in an armoured gorge casemate caponier, and in fieldworks behind some natural salient screen in front of the general fire line. Their sudden leap into prominence is no doubt partly due to the success at Port Arthur of the famous "Open Caponier No. 3" (Hachi-maki-Yama), now known as "G," where a couple of field guns and a couple of machine guns thus mounted gave such trouble to the Japanese that they were compelled, for the first time in the history of war, to use 500-lb. shell from 11″ howitzers against simple earthworks.

Cover for Field Guns.—The chief tendencies in recent types of artificial cover for guns are in the direction of concealment, better flank traversing from oblique fire, and blinded cover for detachments and ammunition. The formal battery is as extinct as the formal fire trench, and a good hidden shoot with the maximum of protection are the ruling factors. A favourite opening move with the Japanese field artillery seems to have been the standing up of half-a-dozen large sacks filled with earth, (as gabions) to act as revetment to detachment shelter parapets on either side of the gun. In spite of its minor disadvantages the sunken gun pit, without visible parapet, is the normal emplacement, and separate screens to defilade flash and hide the gun shields are commonly provided. Both Russians and Japanese agree as to the importance of providing separate emplacements for night and day use, and spare emplacements in the rifle lines to enable guns to join in the shooting at assaulting mobs. The latter require gun shelters and easy ramps not unlike the types of 30 years ago.

German Field Gun Emplacements (*Fig.* 17, *Plate* IV.).

Battery without parapet to fire over ground level, sunk 2′.8″ at gun emplacements and 5′.7″ at shelters. Similar to the gun pits used by us for 4·7″ guns at Modder River Camp in 1899.

Russian Field Gun and Howitzer Emplacements (*Fig.* 18, *Plate* IV.).—The types of Russian field gun and howitzer emplacements are principally of interest from the practical simplicity of their trace and the extent to which blinded cover is illustrated. The illustration of cover for an ammunition limber or wagon (*Fig.* 18(1)) close to the gun is of special interest since so many armies have left this point to the long list of brilliant improvisations expected at short notice on the battlefield.

SUMMARY.

Time will not permit of any examination of the many recent developments of interest in connection with other branches of field engineering, such as searchlights and other field illuminations, land mines and explosives, field tramways, telephones, alarm signals, tools

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and materials, bridging, and numerous subjects of equal interest, and it only remains briefly to sum up our own situation with regard to field engineering to-day.

If in the course of the examination of a few recent types of works there may have been an apparent tendency to dwell unduly upon the material means of defence or attack, it must not be thought that the paramount human element, or the spirit of the man who is "out to win," have been overlooked or ignored.

We know well that the best instances of good defences in history owed but little to the skill of the engineer as compared with the valour of the man behind the gun, yet it is still the duty of the engineer to apply his skill in seeking for strength, and still further refinements of strength, and to place them at the disposal of the man who does the shooting—to use or not to use—as he may think best for the occasion. The strength of field engineering, like the paint on the artist's canvas, produces nothing of value unless it is applied in the right place, in the right quantity, at the right time, and of the proper form and colour. Otherwise it remains, as the Malay idiom expresses it, "of no more use than a shield in a pawnshop."

Whatever critics may say to the contrary the defences constructed by the Russian engineers around Port Arthur were immensely strong; far stronger than their own constructors thought them to be; but they were not in harmony with the spirit of men who are determined to conquer, not merely to baffle their enemy. The science of field engineering applied in the true spirit appears to aim at supplying the means for that economy of force which enables the skilled jiu-jitsu wrestler to divert the ill-balanced strength of the impetuous giant in such a way as to hasten his downfall.

The field engineer must however be careful that it is the enemy, and not his own side, that he arranges to mystify, mislead, and surprise; and all his schemes should have that stamp of effective simplicity which will provide the maximum of opportunity for the *average* soldier, led with *average* skill, to inflict the maximum of loss upon the enemy. The good fighting man, now, as always, can make the best of his opportunities from moment to moment, though the best of soldiers cannot to-day ignore the spade and win through with rifle alone. It must always be remembered that it is the duty of the engineer to provide the soldier of the line with the assistance he *wants:* not something which the engineer thinks he *ought* to want, and is lucky to get. It is not enough for the engineer to set the stage and have his own lines by heart, he must rehearse the play from the very beginning with the gunner and rifleman present on the stage in full costume, or he may find at the first public performance, like the Austrian engineers at Königgrätz, that he has forgotten to inform the rest of the caste where the performance is supposed to take place, and where the properties are kept.

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In this country we are perhaps fortunate in escaping the fatal magnetic attraction of cramped and obsolete types of land forts, which so often throughout military history have administered the slow poison of defeat to those who put their trust in them. But for this very reason it is all the more necessary for us to be fully prepared with matured plans for the rapid and intelligent anticipation of events, and for the use of provisional defences applied so skilfully that, however quickly the decisive point for using the leverage of one of our striking forces may be moved, that lever (the striking force) may always find a strong and tactically opportune fulcrum against which to bear at the decisive moment.

It is abundantly clear that, as fighting goes to-day, it is possible to extemporize effective fieldworks both from the smallest beginnings and in a comparatively short time; and that such works, if used so as to develop to the full the power of the modern firearm, possess enough of the passive strength of permanent fortress works for resistance, while they are of far greater value for making good in the wake of the offensive, owing to their being strategically sounder and tactically more opportune. But such works can be carried out *only by engineers trained for this purpose.*

The master-thought in all education in the use of the spade should not be that men well entrenched can *resist* the attack of several times their number, but that men who are trained and equipped to use the spade so as to increase the power of their other weapons should be able to surround and destroy or capture a larger force which has not this advantage.

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THE OUDH AND ROHILKHAND RAILWAY VOLUNTEERS.

Part of the Armoured Train.

A Corner of the Bivouac.

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THE OUDH AND ROHILKHAND RAILWAY VOLUNTEERS.

By THEIR COMMANDANT.

ANOTHER year has rolled over the Oudh and Rohilkhand Railway Volunteer Rifles since the first notice in regard to them was published in the *R.E. Journal;* and although their conversion into Royal Engineer Volunteers (Railways) is still only "under consideration," it is now at least officially before the Government of India, and another short account of the year's work of a body of men, who hope one day to be linked with the bond of the Volunteer to the Corps, will, it is hoped, not be without interest.

The year, like most in the history of a Volunteer regiment, has had its encouragements and its disappointments; among the former being the loan of a Maxim gun for instructional purposes by the Lucknow Brigade, a long-deferred visit from the Inspector-General of Volunteers, and many kindnesses and much hospitality from the brigades and Regular regiments that the corps has come into contact with, both at its headquarters and elsewhere. About the latter, its disappointments, we will hope least said soonest mended; even obsolete weapons will finally refuse to work some day, and it is to be hoped that when the said day comes the replacements may be less obsolete and that the corps will not be "billed!"

The machine gun was of course eagerly taken up, and there were very soon squads—with a leavening of old soldiers—reasonably well versed in Miss Maxim's little ways and able to keep her in a good humour through quite long periods of continuous work: while as soon as the Inspector-General's approaching visit was announced it was decided to push on with a project that was already on hand for a dummy armoured train, and, with the cordial co-operation of the other Volunteer corps in Lucknow, to give the General an example of what might be accomplished in the way of special railway training for Railway Volunteers.

Work was therefore started at once in the shops on the construction of what is described above as a "dummy" train, but what is more correctly the nucleus of a real one without either the armour, or, for the time being, the 12-pounder; while outside, the weekly parades were devoted to placing the 5-mile stretch of line between the Gumti River at Lucknow and the next station—Malhour—in a state of defence.

On one bank of the Gumti a much improved sleeper-and-sand-

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sandwich blockhouse, of the type illustrated in the *R.E. Journal* of July, 1910, was built by the Loco. and Carriage Company in the course of eight hours work, while elsewhere along the line other defences were constructed, some of them as having been built in a single afternoon, being of particular interest in showing what could be done in a few hours in an emergency, with materials, previously filled sand-bags, etc., railed out from Lucknow.

The blockhouse when completed was tested at close quarters with ball at what looked like its weakest spots, but resisted penetration successfully.

The armoured train is modelled on South African experience, but has been built of old broad gauge 4-wheeler stock instead of the South African metre gauge bogies, and has a Maxim gun truck fore and aft patched up out of old covered goods wagons, with, for the present, a most excellent dummy 12-pounder, which has had the honour of deceiving at least two generals as to its nature even at fairly close quarters! A photo of part of the train standing in the carriage and wagon shops accompanies this article, and shows one of the Maxim gun trucks with its infantry escort truck and the 12-pounder, next to which comes the end of the officers' carriage which accommodated the inspecting officers at the inspection. Since the 4-wheeler wagon, particularly of our old types, does not admit of many rifles in addition to the Maxim gun barbette, the balance of the infantry garrison of the train is carried in escort trucks, linked to the Maxim trucks, and with an armoured way between them.

There is some advantage in this division of 4-wheeler stock for the purpose as compared with a bogie, for the latter is an acknowledged "beast" to re-rail under difficulties, and by freeing the coupling between the two wagons the escort truck can if necessary be separated, half the armoured way then acting as a door to close the opening in the end of each wagon, so as to enable it to be defended independently if necessary. The train has now been fitted with special couplings to enable any likely "cut" to be performed without exposing any of the crew.

What, I fear, looks like a flag in the photo, is really the searchlight emplacement, at present, I regret to say, empty.

It was only just possible to turn the train out by the date of the inspection so that little previous practice of any sort was practicable, but a lecture was given to the officers of the corps on the handling of the train, and tactical notes were distributed; and although the enemy no doubt scored a "derailment" in the subsequent sham fight, this comes all in the day's work of an armoured train, and some useful experience was no doubt gained in this kind of work.

Opportunity for realistic practice is the difficulty on an open line as everything has to be naturally restricted to suit the time table, with the result that operations have to be somewhat rushed.

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On this occasion the train was manned by a railway 12-pounder gun crew, road repairing and re-railing working parties, a telephone section, and one Maxim gun section, while the Lucknow Volunteers found the second Maxim gun and most of the infantry garrison. It ran out to Malhour, dropping the garrisons of the posts *en route* before a passenger train, and hostilities commenced as soon as this latter train was "through." The most important points on the section were the Gumti bridge, Malhour station, and a bridge about 1½ miles from the Gumti, each of which was strongly defended. In addition to these, defensive posts were constructed at either end of a cutting about a mile from Malhour intended as a "harbour" for the train and there was one other intermediate post. Each of these posts were tapped to the ordinary telegraph wire by means of field telephones, and could thus intercommunicate between themselves, and, when necessary, the train with them by means of the train telephone and a bamboo and clip arrangement, enabling connection to be made in a couple of seconds with the wire used by the 'phones. The inspecting officers examined the defences of the cutting, and news then came by 'phone that a party of the enemy were interfering with the track between the Gumti and the intermediate bridge referred to above, so, as there was no news from elsewhere, the train pushed down the line in that direction. As a matter of fact the great bulk of the enemy (who consisted of the majority of the Lucknow Volunteer Rifles and the Lucknow Troop of the Oudh Horse) were lying up close to the cutting, and as soon as the train proceeded on its way they attacked in force and the garrison was ordered (or thought it was) by the local umpire to "quit." On reaching the next post, news was received over the wire of the plight of the west post of the cutting, and the train hurried back, and found a fight still raging in the vicinity of the post. As it was now almost dark and impossible to distinguish at any distance between friend and foe, it was decided to push into the midst of them, detach the leading Maxim truck, and withdraw the train with the 12-pounder to come into action after the enemy's position had been determined. In doing so the leading vehicles passed slowly in the dusk over what had been settled upon as the sign of wrecked track, and it being now very late the "Cease Fire" had to be sounded, and friends and such foes as could be found railed back to Lucknow.

In November a team of 12 men was sent to Meerut—the "Bisley" of Upper India—and came back with one cup, two first prizes and two medals in connection with the match Regulars *versus* Volunteers in which the latter were victorious, besides sundry smaller prizes; so it was quite satisfied with its achievements.

Almost immediately after the Christmas holidays, on January 6th a move was made into the annual camp, held this year some 9 miles from the Armoury on the further (left) bank of the Gumti River near

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the camp of 1910. The corps for the first few days worked by itself, the task first undertaken being the entrenching of a position, each of the three companies in camp constructing a length of trench the first day, attacking it with blank the next to show up defects, and then, after remedying anything desired, equipping it with earthenware jars or "chatties" to act as targets for the following day's field firing. Part of each trench was loopholed and part purposely left without overhead cover to show the effects to the men, and the different companies further adopted different types of head cover.

On the third working day, each company was directed with ball against the trench of one of the other companies, in addition to which the Maxim gun was dragged out 2 miles from camp (on its parapet mounting) to take part in covering from our left flank the advance against the trench. The very high percentage obtained this day of 19 per cent. of hits to rounds fired was no doubt largely due to fire being permitted up to about 150 yards range; (from which distance the trenches were "rushed" with fixed bayonets,) but it also shows general good shooting amongst the great bulk of the men in the ranks.

Next morning we were reinforced by a troop of U.P. Horse, two guns R.H.A., and three companies Lucknow Volunteer Rifles, and ordered to seize a ferry on the Gumti on the right flank of the Lucknow Brigade which was operating against a flagged enemy some 2 miles from the right bank of the Gumti.

The movement was opposed by two squadrons of British cavalry, and began auspiciously for the detachment as its guns caught the cavalry crossing its front at about 1 mile range in close order apparently to seize our field firing trenches. The enemy then seized a village, and after some fighting there fell back slowly on to river where they eventually got hemmed in and the "Cease Fire" was sounded, all except the Oudh and Rohilkhands returning to their various camps and quarters.

The Railway Corps sent officers over the river to get into touch with the brigade and report the result of the day's work, and went itself into bivouac for the night in a guava grove, all ranks making very neat *tentes d'abris* out of two blankets laced together along one edge, and stretched over a string and two bamboo sticks, which formed part of the "mobilization" equipment. The third blanket was used to wrap around the three occupants.

The general appearance will be seen from the photograph showing a corner of the bivouac.

The orders received from the brigade were to cross the Gumti at daybreak and join the right flank of a position they had taken up covering Lucknow; and this was accordingly done, the men crossing in country boats, and the horses and mules swimming.

The junction with the brigade was effected without incident, and

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the corps received a portion of the defensive line covering a ford over a tributary of the Gumti. The enemy were, however, unkind, and attacked the extreme left flank, and after this had become apparent, our right, including the Oudh and Rohilkhands, was ordered to move north and take part in an attack on the enemy's left, in the course of which it saw and took part in some very interesting work.

About 2 o'clock in the day the operations came to an end with a "draw," our force having rolled up the left flank of the flagged enemy, and the enemy having equally rolled up ours; and all the troops dispersed, the Regulars to Lucknow, and ourselves to our camp. When we got back that evening about 5 p.m. we had covered something over 16 miles all over rough and roadless country, and with only one "casualty" which wasn't bad going.

It had been intended to strike the camp next day, but there being some difficulty over transport and a very general desire to extend the camp, it was eventually decided to delay the return by one day, and instead of the march back the G.O.C. Lucknow carried out his inspection, the battalion forming outposts during the morning, and practising ceremonial in the afternoon. The next day the men returned to Lucknow, marching in in good style and many of them genuinely sorry that the camp, which including the marches in and out had lasted nine days, was over.

There is no doubt that a great deal of value is learnt by many during these outings, not only in the actual drills and manœuvres but also through the odds and ends of practical work that have to be carried through to effect these manœuvres. Getting the baggage out for the bivouac, for instance, was no easy job. The only mules we had the loan of were for water and tools, military transport failed, and country carts had to be commandeered: the route was roadless and intersected with nalahs and the baggage guard had frequently to dig roads for themselves, take the bullocks out from half the carts to double team the remainder, and so on. Again, the country was largely unknown and opportunity was taken for instructing in military sketching, engineering officers already well acquainted with deliberate railway surveying, etc.; their work being utilized in the subsequent marches and operations.

The rest of the season was devoted to the usual routine. An occasional "tactical" afternoon, and the rest a much-needed "rubbing up" in the handling of arms and movements in company drill; more especially with a view to bringing on the non-commissioned officers. This ended towards the end of March with an examination of two officers and a number of N.C.O.'s for their "Proficiency Certificates"; the Regular subaltern's "a" and "b."

The only exception to the above was at Bareilly where the O.C. Volunteers, who had been unable to come into the regimental camp, arranged to join the Bareilly Brigade on manœuvres with a section of

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25 men—many of whom had already done the regimental camp. Owing to the hospitality of the Seaforth Highlanders, to whom they were attached, they had a most enjoyable three days, ending in a night march and attack at dawn on the details left in Bareilly.

During the year we have lost no less than four youngsters through enlistment. One of these has gone to the Seaforths and is doing well. One of the others to R.H.A.

Of the railway officers no less than six are in the ranks awaiting their turns for commissions, and all we lack are Sappers ready to utilize their professional qualifications in helping on the rest of the corps. During part of the camp a Military Works officer joined us as a guest, and though unfortunately he could not come till the digging was over, was able to help afterwards in the sketching work, etc.

The principal feature of the past year has been the great increase in the efficiency of both the company officers and the men as a result of the new musketry course. This is based on the Regular course, and, like it, divided into an instructional period and a "test," the former being under the company officers. As a result, for the first time on record the company officers have taken a keen personal interest in the musketry training of their companies, a work which hitherto has invariably (practically under the *Regulations*) been left to the paid staff. The cessation of the *rôle* of figure-head for the company officer, and the greater incentive to the ordinary bad and indifferent shots to do well when working under the eyes of their own officers, has been of a value to both officers and men that it would be difficult to reckon too highly.

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THE BRITISH MILITARY MISSION IN EGYPT, 1798—1802.

THE following interesting documents were found amongst a number of papers which originally belonged to Lieut.-Colonel Sir C. Holloway, R.E. They refer to a little-known Military Mission which was despatched to Egypt under Brig.-General Koehler, R.A., and in which the Corps played a conspicuous part.

The mission was originally intended to assist the Turks in expelling General Buonaparte and the French Expedition from Egypt in 1798, but, as this task proved impossible, the British Expedition was despatched to Egypt in 1800 under Sir R. Abercrombie, and General Koehler was ordered to assist by every means in his power.

General Koehler died early in 1801 and Major Holloway, R.E., then assumed charge of the mission and commanded it until the end of the operations.

The documents reproduced consist of Lord Granville's original instructions to General Koehler, and a letter from him in October, 1800, telling of the intended despatch of Sir R. Abercrombie's expedition. Two letters from Capt. T. Lacey, R.E., giving a description of the Turkish advance and defeat near Cairo in March, 1800, and of a battle near Belbeis in May, 1801. There is also a copy of Major Holloway's summons to the French garrison at Cairo in April, 1801, and a letter from Capt. (afterwards Sir A.) Bryce giving details of the preparations made for the attack of Cairo. Finally Major Holloway's detailed report on the operations is added, the original MS. of which was found amongst some old records in the Institute, as also a report on the defences of the Dardanelles, submitted to General Koehler by Major Holloway, R.E., and Major Hope, R.A., in September, 1799.

(1).

*Instructions from Lord Granville to Brig.-General Koehler, R.A.**

DOWNING STREET,
November 11th, 1798.

To BRIGADIER GENERAL KOEHLER, etc., etc.

SIR,

His Majesty having resolved to send a certain Proportion of Military Stores, with a number of Artillery and Engineer Officers to

* The orthography, etc., is shown as in the original MSS.

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the assistance of the Ottoman Porte, in order the better to enable that Government to prosecute the War in which the Grand Signior is engaged in common with His Majesty against France ; and having been pleased to make choice of you to take the Conduct of this Expedition ; I am now to convey to you such Instructions as may appear to be necessary for the regulation of your Conduct therein.

Immediately upon receipt of these Instructions, you will proceed by Land to Constantinople, with the greatest possible Expedition ; taking with you as many of the Officers, placed under Your Command, as you may think proper, and leaving the remainder, together with all the Stores, to go in a Ship which the Lords of the Admiralty have received His Majesty's Commands to prepare for their transport to the place of their Destination.

Your knowledge of the Country to which you are going, and your Experience of the Manners and customs and Prejudices, political and religious, of the Government, and of the Inhabitants, will enable you to adopt and prescribe to the Officers under Your Command, the proper mode of presenting yourself, and of opening the objects of Your Mission to the Persons who may be appointed by the Grand Signior to communicate with you ; as well as the proper Demeanour to be preserved during your Residence in the Country.

But upon these and all other points of a similar nature, you will refer in the first Instance to Mr. Smith His Majesty's Minister Plenipotentiary at the Porte, and will conform yourself to His Suggestions.

You will represent to the Turkish Government, the strong and lively Interest which His Majesty feels for the Success of the Arms of the Porte, and His Desire to contribute so far as in Him lies, to the vigour and efficiency of its Military Operations ;—for which purpose you are commissioned to offer every Aid and Information in your Power, and are to act to the best of Your Ability, and to the Extent of the Military Means entrusted to your charge in any Quarter, and upon any Military Service which you shall judge to be conducive to the great objects which His Majesty has in view.

With regard to the nature of the Service which you may have to undertake, the peculiar circumstances of the case render it impossible to give you any precise Instructions.

The Defeat or Destruction of the French Army in Egypt, and also of their Transports and other Vessels in the Port of Alexandria, and elsewhere, will naturally engage Your first Attention. And you will be particularly solicitous to direct the efforts of the Porte in such a manner, as may destroy even the Possibility of General Buonaparte's using any part of his Force to the annoyance of the British Dominions in India. Subject to these Remarks, you will chearfully accept whatever Destination may be offered to you in which you can most effectually be employed against the Common Enemy ; and you will

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concert, as well with Mr. Smith, as with Sir Sidney Smith, or the Commander of His Majesty's Squadron in the Levant Seas, such Operations as it may be expedient to suggest to the Porte, for the Expulsion of the Enemy from the Grand Signiors Dominions, and generally for their Annoyance and Destruction there, or in the Coasts and Islands thereto adjoining.

You will communicate from time to time to me directly, and constantly to His Majesty's Minister at the Porte, an Account of the operations in which you may be engaged, and also of those of the Turkish Arms in whatever part of the Empire; and of the general Plan of Operations and success of the Campaign.

Of the Military Stores which you carry out with you, such as are of Ornament only, are in the first Instance to be presented to the Grand Signior, with whatever Formalities may be necessary on the occasion, as a present from His Majesty, and as a Proof and Pledge of His Friendship and Respect for that Monarch.

That part of them which are destined for active Service, you will endeavour to keep as much as possible under your own direction until you shall have succeeded in instructing the Turkish Officers in the method of using them with Effect; and you will follow your own Discretion, and the Judgement of His Majesty's Minister, as to the Propriety of ultimately making them over to the Turkish Government, or as to the Moment at which it may be expedient to do so.

The Board of Ordnance having appointed a Commissary to superintend the use of these Stores (but subject entirely to your Control as to the mode of using them) and to account for them to the Ordnance. You will of course give him a regular Discharge for such Articles as you may from time to time part with to the Porte or Its Officers.

I am with great Truth and Regard,
Sir,
Your most obedient humble Servant,
GRANVILLE.

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(2).

DOWNING STREET,
10*th October*, 1800.

To GENERAL KOEHLER, etc., etc.

SIR,

The King having, on a consideration of the present state of Egypt, determined to send thither a considerable body of Troops under the command of Sir Ralph Abercrombie, I have received the King's commands to transmit to you, for your information, an Extract of the Instructions which have been given to that Officer for the regulation of his conduct in this important service. And I have to signify to you

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His Majesty's pleasure that you afford Sir Ralph Abercrombie every possible assistance which can contribute to the success of the enterprize in which he is engaged. For this purpose it is His Majesty's pleasure that you regularly transmit the most accurate information of the state and operations of the Turkish Army in Syria to Sir Ralph Abercrombie, and that you should in all respects govern your future proceedings by such orders as that Officer may think it expedient to give you on his arrival in the Levant, or by any previous communication.

His Majesty's Ambassador at the Porte is instructed to correspond with you on this subject; and He will apprize you of the measures he may have taken or may wish you to take for procuring such a number of saddle and draft horses as may be wanted for the immediate use of the Army on its arrival in the Levant; and for such other objects as may contribute to Sir Ralph Abercrombie's success.

I have the honour to be with great truth and regard,

Sir,

Your most obedient humble Servant,

GRANVILLE.

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(3).

Letters from Capt. T. Lacey, R.E., to Major Holloway giving descriptions of the Turkish Advance upon Cairo in March, 1800, *and of the Battle of Belbeis in May*, 1801.

CAMP AT JAFFA,
21st July, 1800.

To MAJOR HOLLOWAY, etc.

Report in compliance with Orders of Major Holloway, Comdg. Royal British Engineer in the Dominions of the Grand Signior, of Military Occurrences to which I was an Eye-Witness, from the time of my presenting Dispatches that had been entrusted to me for the Grand Vizier, by His Excellency the British Ambassador at the Ottoman Porte, to the period of my arrival at Jaffa, after the total Rout and Defeat of the Turkish Army.

I presented my Dispatches to the Grand Vizier, at his Camp at Belbeis, the day after my arrival there; viz., the 9th March, 1800. From this period to the 12th of the same month we continued encamped at Belbeis, myself remaining under Mr. Morier's tent; but without being made acquainted with the interior arrangements or intended operations of the Army; and only employing myself to assist Mr. Morier in copying Dispatches and Advices, which, not being of a military nature, I do not here feel it necessary to disclose. On the 12th March, the Army moved towards Cairo; and from this event,

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I shall proceed to copy from my Note-book such remarks as circumstances enabled me to collect, thinking this the best mode of conveying the information now required of me.

12*th March*. The Army leaves Belbeis and marches towards Cairo, the place for the new encampment having been proclaimed through the Camp two days before; when it was left to all to take up their new ground at such different intervals of time and in such order as they thought proper, and without waiting for the movement of the Grand Vizier. At three hours distance from Belbeis, we arrived at an Arab Village called Lavanhie. A flat loose sand lay all the way on my left hand, with the view bounded by a ridge of low sand Hills, the confines of the Desert of Suez. On my right hand nothing but cornfields of the highest culture, a vast appearance of abundance, and many Arab villages shaded by tall Date trees, raised on little mounds above the plain; built of sun dried bricks, and furnishing excellent positions and materials for Military purposes. The country everywhere is well adapted to the operations of cavalry. In the afternoon, arrived at our new camp, six hours distant from Belbeis, no order observed in fixing it, it looks like a fair. This place is called El Hank.

13*th March*. Expecting an attack from the French. The Grand Vizier, and all the Council in the greatest alarm, they send forward ten thousand men as an advanced guard, or army of observation; but have no system, and are even too ignorant to make the most obvious arrangements, they know nothing of disposition. I offered my services to the Grand Vizier, and proposed to find my way into Cairo under some false pretence, in order to view the country round about, to reconnoitre the works, and gain information from within, but this, after some consideration, was rejected.

14*th March*. Received a present of a shawl and other rich cloths from the Grand Vizier, in consequence perhaps of what passed yesterday. I was sent for to receive this in the tent of the Reis Effendi he asked me, why I had not visited him before. They have just sent to El Arish for their field train, they have not at present more than twenty pieces of small bad ordnance, and not even ammunition enough for them.

15*th*, 16*th*, 17*th*, 18*th March*. Turkish Ministers holding absurd conferences with the Enemy, by which the latter only endeavour to gain time, in order to collect their troops from Upper Egypt and the Delta.

19*th March*. Employed in writing letters to Major Holloway and my Lord Elgin.

20*th March*. In sight of Cairo and the Pyramids, a little skirmishing in front, and the French Army drawn up in a fine plain before us. Mr. Morier sends off a Tartar to Sir Sidney Smith, and I seize the same opportunity to send accounts to Genl. Koehler, on a leaf torn from

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my pocket book. The Grand Vizier permits me to reconnoitre, and sends Officers of his own suite along with me. Very much in want of a Dragoman, my own having slunk away, to remain with the baggage. I placed myself near the right of the enemy's lines, and found their chief force compactly drawn up, to the amount of about seven thousand men, with plenty of cavalry and artillery, and seeming to be making dispositions on their left to cut off our advanced parties who were dispersed here and there, without connection or design, and of no use either to annoy the enemy, or to prevent their advancing. Our artillery moved forward at the same time that I did, and were placed in front of the enemy's lines, at the distance of about one thousand yards. As I had placed myself about half way between these guns and those of the enemy, I could perceive that our own did no execution at so great a range, while the enemy's guns, of much larger calibre, threw their shot quite home, and very soon dismantled two of ours. The enemy were drawn up in two lines, the one a little advanced before the other, and the right of the second line so far out flanking that of the first, that their Artillery from this quarter also had effect upon us. Having finished my observations I returned to urge the Grand Vizier, immediately to form his infantry, and to send forward some artillery to an advantageous situation, at the extremity of a grove of date trees, near the enemy's right. I brought him also one of the enemy's balls, thrown from their pieces de huit to convince him that our small ordnance should be placed much nearer the enemy, and in the spot I had just chosen for them. But the Grand Vizier thought he had done enough for that day, and after enquiring only after the enemy's numbers, seemed determined to return to his Camp at El Hank, supposing no doubt that the enemy would permit us to do so unmolested. Soon after however, the enemy moved forward; deploying, and extending their front and with battalions advancing round our right in a position either to cut us off, or to drive us immediately to the Desert, where the enemy had five or six hundred of their bravest troops mounted on camels, quite sufficient to have destroyed the few of us, only who then remained with the Grand Vizier. Those of the enemy who were coming upon our rear, had been mistaken for our own troops; when I found it necessary to undeceive the Grand Vizier, and to urge him, either to rally and repel the enemy, or instantly to save himself by flight, there was no choice left him so we fell back in the greatest disorder and precipitation towards Salahieh; the enemy pursuing us as far as Belbeis.

21st March. Arrived at Salahieh. Recommend them strongly to maintain this post, at all events, and to keep open a communication with Damiat and by retire thither in case of disaster. Met with nothing but insult and contempt.

22nd March. Wrote to Gen. Koehler all that had passed, and sent

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my letter by Mr. Morier, who was then about to depart to join Sir Sidney Smith by way of Damiat.

23rd March. The Turks in Cairo defend themselves bravely, some resistance also, made by them at Corin. They bring in a few heads, with the uniform of a French General.

24th March. The Grand Vizier directed all those, who had good horses and good arms to follow him. I consequently mounted myself and my servant upon a sick horse, all that remained for me and put myself in the Grand Vizier's suite. I had previously offered large sums of money for a couple of horses or camels and had also made a strong requisition for them to the Grand Vizier, but all in vain and I had the mortification to see Mr. Franchini's Men's conveniences attended to, while I, in the utmost necessity was left either to be massacred by their own disorderly troops, or else to fall a prey to the enemy. At the instant of our joining the Grand Vizier, a general pillage ensued, the troops fought among each other, and only permitted me to escape with the greatest difficulty. I lost all my baggage, with letters, notes, instructions, etc. Soon after we entered the Desert, my horse being without shoes, and having lost a great part of one of his hoofs, fell suddenly lame, and would not proceed further. The Grand Vizier and his Officers had many led horses and trains of camels slightly laden, but offered me no assistance, though it was evident I must perish without it, and had it not been for the humanity of a Mamalouk attached to Ali Pacha, this would certainly have been the case; he placed my servant upon one of the Pacha's Dromedaries, and gave us water and bread from time to time, by which alone we were enabled to cross the Desert.

25th March. Arrived at Catieh.

26th Do. At El Arish.

28th Do. At Gaza. The Army again encamped to the amount of ten or fifteen thousand Men, having left many to be destroyed by the Enemy or to perish in the Desert.

29th March. Sick, and very ill treated.

30th, 31st Do., and *1st and 2nd April.* Do.

3rd April. Required to translate letters received from Lt.-Col. Murray by the Grand Vizier, and to return an answer, the Dragoman of the Porte treating me all the while with the greatest scorn and indignity.

4th April. Sick.

5th Do. The Army marches to Jaffa, myself not in a condition to continue with them.

6th April. Sick.

7th Do. Resolved to follow the Army, though still very weak, and sent to the Pacha to request a guide to conduct me to Jaffa, but this was refused me. The treatment I experienced determined me to set off without one. Arrived at an Arab Village with a Turkish garrison, where they would hardly permit me to enter.

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8th April. Obliged to set off in the middle of the night, to be taken before the Pacha of Jerusalem as a spy. Was permitted to continue my route, but having been taken out of my way, lost myself, and was obliged to hire guides from village to village, where the Bedouins were then plundering and the Turks at war with them.

9th April. Having been well treated by the inhabitants, I proceeded towards Jaffa, and arrived in the evening, in so bad a state, that I was obliged to be taken off my horse and conveyed to bed immediately.

THOS. LACY,
Lt., Rl. Engrs., and Captn.

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(4).

CAMP AT BELBEIS,
17th May, 1801.

To MAJOR HOLLOWAY, Comdg. British Forces, Camp Grand Vizier.

SIR,

I have the honour of reporting to you, that on the morning of the 16th about 7 o'clock, I quitted the Camp at Belbeis, accompanying Mahomed Pasha, who with the troops under his command, moved forward to support the advanced corps under Tahir Pasha. After proceeding nearly three leagues, on the side of the Desert, we joined these corps about half past eight, at which instant they were engaged with the enemy and had been so for some time previous. The enemy were posted near a village and wood of date trees on the skirts of the Desert halfway distant between Belbeis and El-Hank, while Tahir Pacha with his Albanian infantry occupied a village near them, maintaining a brisk cannonading and constant skirmishing. When this had continued near an hour, the troops under Mahomed Pacha, who had halted during this time, advanced with three light field pieces, and the enemy quitted their position. The Corps of Dehlis and Mamalouks had posted themselves upon hills in the Desert on our left. The enemy then moved towards these hills the first body of them, which formed their right wing, gaining the heights, where, formed in hollow square, they protected the rest of their army as they filed from the wood and the village. While this was effecting the Grand Vizier arrived with a fresh body which joined Tahir Pacha, whose troops, with great alacrity and bravery, had previously possesed themselves of the position the enemy had quitted. The enemy were now in the Desert continually shifting their ground, and pressed on both flanks. Tahir Pacha on their left and the cavalry on their right. In this situation of things they quitted the heights and retired further within the Desert, their left being annoyed by the guns of Tahir Pacha. From this period the enemy made no further use of their artillery, but retired, on their left, along the desert with great rapidity, and sometimes in disorder. Their infantry laboured thro' the sands

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evidently with great difficulty, the Turks hovering on all sides, and continually harassing them, and Tahir Pacha's troops keeping the cultivated country, extended themselves far beyond the head of the enemy's column. In this state the enemy were pursued beyond El Hank, and for a distance of eight miles they must have been in constant apprehension of being cut off, and entirely routed. The enemy amounted to nearly five thousand, composed of infantry, cavalry, and Hedjins (?) and with about twenty pieces of Ordnance, guns and howitzers. I left El Hank an hour before sun-down, when the pursuit had been given up, and the troops under Tahir Pacha were retiring to their quarters.

Sir,

I have the honour to be

Your Most Obedient, Humble Servant,

THOS. LACY,

Captn., Royal Engineers.

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(5)

Copy of Major Holloway's Summons to the French Garrison in Cairo.

AU CAMP IMPERIAL OTTOMAN DE SON ALTESSE LE SUPRÈME VIZIR-EL-ARISH,

3eme *d'Avril*, 1801.

Les derniers Succès des Armes Britanniques et Ottomanes dans le voisinage d'Alexandrie ne peuvent pas vous etre inconnus; ni l'Approche d'une grande et puissante Armée sous Son Altesse Le Suprème Vizir: par lesquels toute possibilité de Secours vous est coupée.

Son Altesse Le Suprème Vizir par des Motifs d'humanité et par un desir d'epargner le Sang des Braves Troupes, m'a donné des Pouvoirs d'offrir à la Garnison de la Citadelle de Caire les termes suivans.

La Garnison doit se rendre prisonnière de Guerre dans l'espace de 24 heures àprés la reception de cette Sommation.

Les Canons, Mortiers, Munitions de Guerre et de Bouche, Fusils et toute especе de Munition et Proprieté publique dans la Citadelle doivent etre remis dans leur etat actuel, au Commissaires qui seront nommés pour les recevoir.

Les Vies des Français qui composent la Garnison seront sauvées, leurs personnes respectées et un transport à la France leur sera fourni.

CHARLES HOLLOWAY,
Du Corps Royal de Genie et Major
Commandant les Troupes de Sa Majesté
Britannique avec l'Armée Imperiale Ottomane.

À l'Officier Commandant les Troupes de la Republique Française, qui composent la Garnison de la Citadelle de Caire.

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(6).

Letter from Capt. Bryce giving details of the stores, etc., prepared for the attack on Cairo.

CAMP NEAR TERRANI,
29th May, 1801.

SIR,

I have received by Lieut. Col. Kempt the Commander in Chief's Orders to make preparations for the attack of Cairo which has been determined on in concert with the Vizier. And am informed at the same time that you intend to take the Command of the Corps of Engineers on this occasion.

I will not pretend to conceal my dissapointment on being thus a 2nd time unexpectedly superseded on the eve of a Seige, after having been so long in command of the detachment under very uncomfortable circumstances, and after having left England with the Boards warrant to command. More especially as your diplomatic duty appears to be more distinguished and preferable to the other. I hope however that I need not assure you that these circumstances shall not prevent my exerting myself as much as possible in forwarding the necessary Stores, and making such arrangements as seem to me best calculated to forward the service in which you are engaged.

It is much to be regretted that circumstances (with which you probably are acquainted) prevented anything on this head being settled before we left Rhamanie. The Stores would during this time have been collected and measures taken for their being forwarded. At present a small proportion are with the Army here, some at Rosetta, some on board the Transports at Aboukir, the remainder at the Camp near Alexandria. So that owing to the great difficulty of getting over the bar of the Nile, The small depth of water on Lake Maadie (by which the Stores from Alexandria must come) and the difficulty of procuring enow of Germs I apprehend much inevitable delay. I shall set out for Rosetta to-morrow that I may be enabled to give the necessary directions on the Spot. In the mean time I enclose a list of what I propose forwarding to you. In making out this proportion I have adverted to the propriety of reserving a certain Quantity of Stores for the Siege of Alexandria as well as the probability of your being supplied with some part of certain Articles by the Viziers Army. And the great difficulty of procuring sufficient tonnage to forward them. If therefore it should appear to you inadequate, let me know as soon as possible and at the same time arrange with the Qr. Mr. General the additional Germs necessary for their conveyance, or if you observe anything in

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the list not absolutely necessary the sooner I am informed of it the better. I have been exceedingly anxious to avoid as much as possible in our operations a greater expenditure of Intrenching Tools, as they are not to be replaced in this country. I hope however for a supply from Malta where Major McKerras left a considerable quantity which I have written for. Very little of my original Stock of pine timber remains having used a great deal for a variety of purposes and having been unavoidably obliged to furnish the other departments of the Army, as well as the Navy, but 4 Ordnance Ships lately arrived have brought 17,000 feet of 3 inch pine plank and 8,000 feet running of Timber 12 × 10, this last is much too heavy but having no other I must send it with two or three Pit Saws, of which I have but four. Lieuts. Birch, Graham, Kennet, Arnold and Lieut. Harrison Asst. Engineer will proceed with the Army to join you, and Capt. Ford and Lieut. Squire from the Army before Alexandria (where I shall have remaining Lieuts. Hayes, Handfield and Dundas). I am sorry that our detachment of Artificers and Labourers is so small being in all 32 of which 8 are Labourers. Those with the Army here will proceed to join you, I understand that you have with you a small detachment, I believe the Army will furnish you with about 100. The list of Stores I have with me here was made out at Marmorin Bay and therefore incorrect as a considerable quantity has been expended since, but I will forward you a corrected list from Rosetta that you may know what is to be had from this Quarter. I must beg you however not to lose sight in your calculations of the time and difficulty in getting Stores from Alexandria to Rosetta.

I have just sustained a great loss here by the death of my best Clerk of Stores, I will however endeavour to send one on to you with two Conductors who are but indifferent. I also send 4 civil Coopers, two of them very good men and fit to be employed in charge of Stores. I have got a great quantity of Staves in bundles for forming Casks, I propose if you think fit and I can find conveyance to send you 300 or 400 bundles and some more Coopers to set them up. I have to request you will excuse this hasty sketch which conveys you as much information as occurs to me at present. I shall be happy to hear from you soon and very happy to do everything in my power to contribute to the success of the undertaking in which you are engaged.

I have the honor to be,
Sir,
Your most Obedient Humble Servant,
ALEXANDER BRYCE, *Capt., Royal Engrs.*

To MAJOR HOLLOWAY, Royal Engineers, etc., etc., etc.

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29th May, 1801.

List of Stores proposed to be forwarded to the Army acting on the Nile.

Axes, felling	... ...	100	Manes wood 40
„ broad	... ...	40	„ pin 10
„ pick	... ...	1,000	Mallets fascine 100
Augers	... ...	10	Mattocks 200
Adzes	... ...	10	Nails, 40 d 8,000
Bills, hand	... ...	300	„ 20 d 8,000
Barrows, wheel	... ...	50	„ 10 d 4,000
„ hand	... ...	50	Pickets fascine ... ... —
Bags sand, bushel	...	40,000	Planes Jack 4
„ „ ½ bushel	...	40,000	„ Trying 4
Baskets ballast	... ...	400	„ Smoothing ... 4
Coals, casks	... ...	4	Rammers earth 40
Candles, lbs.	... ...	56	Rope, coils 4
Forge carts complete	...	2	Rules 2 feet 6
Crows iron	... ...	12	Squares iron 10
Choakers fascine	... ...	30	Spikes 7 inch 10,000
Chisels, sets	... ...	2	Shovels 14,000
Grindstones and Troughs		4	Spades 700
Gimblets, sorts, dozens	...	3	Spare helves, Spades and Shovels 600
„ spike „	...	2	
Hammers hand	... ...	10	Spare helves, Mattocks and pickaxes 300
Handspikes	... ...	40	
Hatchets hand	... ...	300	Saws with files, Cross cut 10
Harness Men's, sets	...	6	„ „ Hand ... 30
Iron of sorts, Cwt.	...	4	„ „ Pit ... 2
Jacks screw	... ...	3	Stones rag 10
Knives, drawing	... ...	6	Plank 3 inch pine, feet ... 8,000
Ladders scaling, joints	...	60	„ 2 and 3 inch oak ... 1,500
Levels Masons	... ...	4	A proportion of such scantling as can be had.
Lanthorns of sorts	...	20	
Line Hambro, skeins	...	10	

(*To be continued*).

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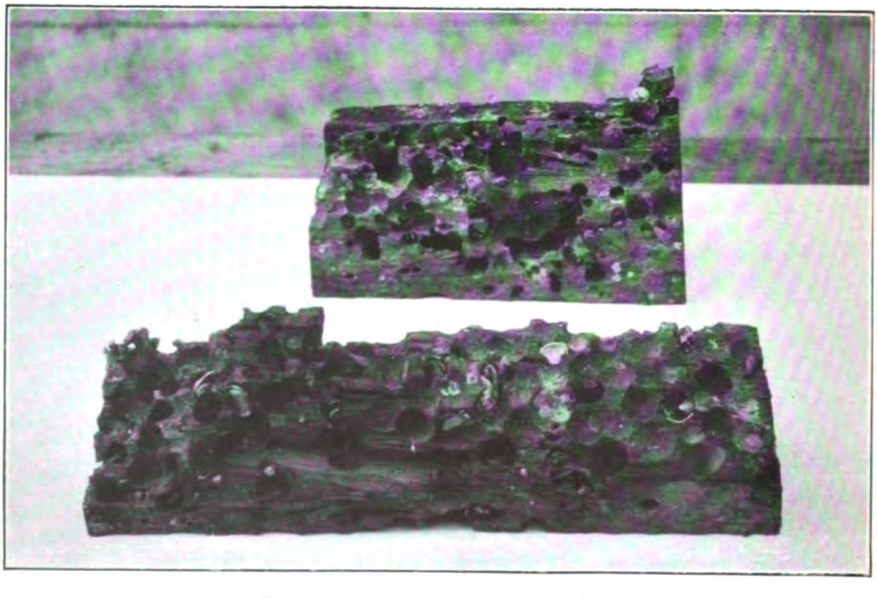
DESTRUCTION OF A TIMBER JETTY BY THE SEA-WORM

View of the underside of the Jetty, showing the condition in which the uprights appeared when the walings had been removed.



Tunnels made by the "Teredo.

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THE DESTRUCTION OF A TIMBER JETTY BY THE SEA-WORM, AND ITS RECONSTRUCTION IN BILLIAN.

By Capt. G. H. Addison, R.E.

Introduction.

In 1904 and 1905 extensive reclamation works were being carried out by the Admiralty on the north shore of Victoria, Hong Kong, in connection with which two timber jetties, 550′ long, were constructed. These were handed over to the War Department, and, with the exception of some 100′ at the east end, are now in use by the A.S.C. and the A.O.D.

In 1909 it was found that considerable decay was going on in the timbers below high-water level. The rapidity with which this increased during the hot weather was remarkable, and, in view of the heavy loads to which the jetties are subjected, it soon became clear that partial repairs would not meet the case. The eastern portion used by the A.O.D., being a year older than the western or A.S.C. portion, was naturally in the worst condition, and in the spring of 1910 it was decided to dismantle and completely rebuild it, leaving intact only the hollow cast-iron piles upon which the structure is carried.

Alternative Methods of Reconstruction.

Three materials for reconstruction suggested themselves, viz. :— (i.), Timber; (ii.), Ferro-concrete; (iii.), Rolled steel sections. Leaving (i.) for the moment and considering (ii.). Although opinion may still be divided as to the chemical action of sea-water on Portland cement concrete and this form of construction cannot yet be said to have withstood the test of time, there is plenty of inferential testimony that reinforced concrete is about the soundest system for new work of this nature. Immense difficulty is, however, experienced in getting such work done locally, and, with unskilled coolie labour, the amount of supervision and length of time necessary would both have been excessive. The scantlings of the various members could not have been safely reduced, so that the cost would have been considerably

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higher than timber. As regards (iii.) the main objection lay in the fact that the original piles have naturally not been driven quite truly in line, the length of the various members thus varying in every bay. This would probably have necessitated marking off, cutting and drilling the ironwork on the spot; work to which Chinese methods and tools are ill-suited, and in which much delay and difficulty would be caused by tides. Moreover, seeing that these jetties are a replica of the Admiralty berthing jetties at Portsmouth, and of very massive construction, it would also appear a work of unnecessary supererogation to embark without excellent cause on entirely new design and calculations. Method (i.) then had much to recommend it, always provided that either means could be found to protect the timber from the ravages of the sea-worm, or that a timber could be found which in itself would be unassailable.

MEANS OF PROTECTING TIMBER.

Many processes both mechanical and chemical have been tried for the preservation of timber. The former, which usually consist in covering the timber with some form of metallic sheeting, were put out of court by the large expense involved. Of the latter by far the best is creosoting, but, so far as the writer knows, the requisite plant does not exist in Hong Kong. The timbers in the existing jetty were tarred, but, as has been stated by many writers, tar alone is not of much use. Colson* points out that the crude naphthas or oils lighter than water are useless as antiseptics and immediately evaporate, whilst the solidity of the pitch renders it incapable of absorption. Coal-tar in distillation is broken up into three groups of products, viz.:—oils lighter than water, oils heavier than water, and pitch. Of these the heavy oils constitute the creosote of the timber yard.

Various patent paints are sold for the protection both of timber and iron under water, in most of which coal-tar and resin play a prominent part. John Rahtzen's introduction of shellac dissolved in alcohol seems to have made a great advance in this connection, and of several paints tested during this work Rahtzen's gave the best results. The writer has it on good authority that some temporary piles of ordinary pitch pine treated with Rahtzen's "anti-fouling" paint were found practically untouched by the worm after five years' immersion in Malta Harbour, unprotected timber during the same period being completely eaten away. None the less any external treatment of this kind can only be regarded as a temporary measure, and would require constant observation and periodical renewal.

* *Notes on Docks and Dock Construction*, by C. Colson, M.I.C.E.

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Varieties of Timber Used in Sea Work.

Greenheart and Teak.—Turning now to the subject of the timber itself. Up to a comparatively recent date greenheart, from British Guiana, and teak were considered, if not impenetrable, at least indestructible. In tropical and semi-tropical latitudes, however, this has been found to be by no means the case. Among many others, cases have occurred at Malta and at Port Elizabeth where greenheart jetties have been so badly attacked as to require rebuilding after comparatively few years.

Australian Timbers.—Several Australian timbers, viz. :—Cypress Pine, Turpentine, Eucalyptus, and Jarrah, and New Zealand Totara have been found immune in some places, whilst in others they have suffered severely. In *Cassier's Magazine*, August, 1910, a case is quoted in Auckland Harbour where 12″ × 12″ piles of the best Australian timbers were eaten right through in seven years. Some temporary piles of white pine were destroyed in three months in the same place. The worm, as is well known, will often not attack timber when there is a softer and more palatable variety in the neighbourhood, and this may account for spurious reputations obtained from time to time.

Bamboo, etc.—It is interesting to note that palms, bamboos and similar timbers are seldom attacked by the teredo, which prefers a more compact wood. Along the Praya in Hong Kong may be seen numbers of flimsy bamboo piers, which appear to withstand both the worm and the weather in an amazing manner.

Timbers that are Proof against the Sea-Worm.

Aranga.—There remain two little known trees, both of which provide timber that would appear to be actually unassailable. These are Aranga (Homalium) from the Philippines, and Billian or Iron-wood (Eusideroxylon Zwageri) from North Borneo. The Hong Kong and Kowloon Wharf and Godown Company, Ltd., have aranga piles driven 25 years ago, which are absolutely sound to-day. The better Philippine woods are, however, becoming scarce, and are strictly preserved by the Americans for their own use. Aranga is consequently impossible to obtain.

Billian.—Billian is one of the most important timbers of North Borneo. A considerable amount is imported into China *viâ* Hong Kong, and it may thus be obtained without much trouble. The above-mentioned dock company's trial billian piles were destroyed some years ago in a typhoon, but they consider it to be the equal of aranga. Colson refers to it as unassailable, and Baterden* says "So far as the

* *Timber*, by J. R. Baterden, A.M.I.C.E., in the Westminster series.

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author knows there is no wood which is not liable to attack by the sea-worm, with the possible exception of billian from North Borneo, and that has not been much used, but appears immune." Billian is a very hard heavy timber of a light reddish-brown colour. Its weight is given by Baterden as 70 lbs. per cubic foot, but tests made during the work under review gave uniform results of 78 lbs. It is rather liable to star shake, and has a considerable tendency to split when driven or sawn; in consequence of which the price of sawn timber is out of all proportion higher than that of rough hewn. The market price varies considerably, but, if obtained direct from the importers, it can usually be had at about $1.50 per cubic foot, rough hewn, or $2.50 sawn one side. For sawn all four sides as much as $7 or $8 may be paid (the dollar varied between 1s. 9d. and 1s. 10d. when these prices were quoted). The Chinese contractors' prices are a good deal higher. It cannot be obtained in greater lengths than 40′ to 45′, or in section about 14″ × 14″ (Baterden says 10″ × 10″, but 14″ × 14″ was supplied for this job, although a good deal had to be accepted that did not comply with specification; wanes of several inches being rather the rule than the exception). The hardness of the wood is remarkable, and the wear and tear to tools used on it is very great.

DESCRIPTION AND EFFECT OF THE SEA-WORMS.

During the dismantling of the jetty there were opportunities to observe the working of the various destructive agents, and the results noted, though probably differing little from many records of a similar kind, may be of sufficient interest to be briefly described here. The damage was almost entirely caused by the Teredo Navalis and the Chelura Terebrans, the latter being by far the more destructive of the two.

Teredo Navalis.—The teredo resembles an ordinary worm with a hard shelly head attached. This head is in two parts, which work on a sort of hinge, and its front edges are very sharp—somewhat like the edge of a fine fret saw. By this means it bores its way into the wood. The hole by which it enters often appears very small from the outside, but once inside the timber the worm gradually grows both in length and girth. The average dimensions, as given by various authors, differ very considerably, but specimens have been measured up to 6′ in length and ¾″ diameter. Once having entered they never work out again, and their size would seem to naturally depend on the bulk of the timber inhabited and the length of residence therein. In the present case the average dimensions were 1½″ by ⅜″, the largest measured being only 2″ by ⅝″. One worm never enters the hole made by another, but always works round, leaving a thin wall. This is frequently torn away by a small crab that preys upon the worm, and so increases the damage to the

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timber. The most serious effects wrought by the teredo were in the lower horizontal walings, which were completely honeycombed to a depth of $1\frac{1}{4}''$ to $1\frac{1}{2}''$ on every side. The uprights were also attacked, though not so seriously. In this case the damage extended from the top of the pile caps (the timber inside the caps was completely immune) to an average height of 2′ 8″. This, as may be seen from the drawing, is about 4′ above L.W., or 3′ 6″ below H.W.; that is to say, approximately mean tide level. The highest marks found in any upright were 5′ 6″ above low water.

Chelura Terebrans.—The chelura is like a minute shrimp, generally $\frac{1}{4}''$ to $\frac{3}{8}''$ in length, and has two long claws, or feelers, with which it attacks the wood. Thousands of these animals will be found in one piece of timber, and their borings are so close together that the slightest action of the waves washes away the surface of the wood. Their invariable point of attack appeared to be a joint, or where pieces were in contact. In the view of the underside of the jetty, it will be noticed that the uprights are eaten right through at a very uniform point. This was the point at which the walings, struts, and uprights were in contact. Similar effects were to be seen on the fender piles. These were untouched below ground level; thence to about 3′ above low water they were dotted with tunnels of the teredo similar to those in the walings, while the chelura had attacked and completely eaten them away throughout the length of contact with the walings.

Limnoria Terebrans.—The limnoria terebrans, though often mentioned as being even more destructive than the chelura, was not found in the present case. It is smaller than the latter and quite different in appearance, though it produces very similar results. It prefers a soft wood, and differs from the chelura in being equally active in cold as in warm latitudes.

Details of Reconstruction Work.

No particular interest attached to the actual work of reconstruction, which was carried out without difficulty. In view of the high price of sawn billian, $7'' \times 3\frac{1}{2}''$ steel channels were substituted for the $14'' \times 7''$ walings, and a few minor alterations in design were made as a matter of convenience, chiefly in connection with the fender piles. Much of the decking was found to be full of dry rot and had to be renewed. This was probably due to the fact that the deck boards were laid so close together as to be touching in many places. In relaying a minimum interval of $\frac{3}{4}''$ was left between boards. Regular attention given to keeping the gaps between boards clean and open will be found to considerably lengthen the life of such decking. Almost all the ironwork was found fit for re-use. The plates and straps below mean tide level had lost on an average ·0035 of their

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weight, but were otherwise in good condition. The steel walings were coated with a mixture of cement and tar; the remainder of the ironwork, and all timbers below H.W.L. were painted with Rahtzen's No. 2 anti-corrosive paint.

It was difficult to determine at all reliably of what timber the original jetty was built. Almost all the timber used for general purposes in Hong Kong comes from Borneo or the Straits, and goes by the general name of "hardwood." Those most generally met with at present are kapor or camphor wood (Dryobalonops Aromatica) from Borneo, and botchow from Singapore. The former, which is typical of these "hardwoods" is described by Laslett* as a moderately hard and tough wood, most useful when used in greatest bulk. He rightly says that it is not likely to be esteemed by engineers or builders. These, or very similar woods, were probably used in the original construction of the jetty. To what extent billian will realize expectation the future alone can show.

* *Timber and Timber Trees*, by Thomas Laslett.

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TRANSCRIPT.

ROYAL ENGINEERS IN CO-OPERATION WITH OTHER ARMS.

By Brig.-General F. C. Heath, c.b., *Inspector of Royal Engineers.*

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I have been asked by General Lawson to talk to you to-day on the employment of Royal Engineers with other arms and kindred subjects. This I am glad to do, because, whatever we may have been accused of in the past, I feel sure you will bear me witness that we are now as keen as any to come out of our shell of exclusiveness and work in with other arms.

The *rôle* of the Royal Engineers is to "help on the show," and this, of course, they cannot do unless they know and thoroughly appreciate what other arms want, but besides this those other arms must realize the nature of the assistance that can be given, lest there be danger of their not asking for what they can get or of making impossible demands; so you see, we must know one another and more than this, the knowledge must be so intimate that help is given, or assistance asked, as a process of intuition. We cannot afford to wait until the time of active service to learn these things, as then everything must go as if by clockwork.

My subject is a dry one I fear, but I trust it may help us to think out these matters.

I daresay most of you remember the days when a field company did not form part of the peace organization of a division, indeed, it is only some few years since all that was changed. In former days it usually happened that a field company was thrown at a G.O.C.'s head just as he was starting for a field day, with the obvious result that he and his staff uttered a bit of bad language and wondered how they were meant to use those d——d sappers.

But now that has all changed, and every division has, you know, as part of it a little battalion of Royal Engineers, consisting of two field companies and one divisional telegraph company, commanded by a lieut.-colonel. The field companies never change stations; the lieut.-colonel usually commands them for four years, and the other officers are with them for not less than three years. They are entirely under the General of Division and his staff for training, so you see it is now their fault if these engineers are not trained to suit their requirements.

I am thankful to say that this new organization has worked a very great change, we are now being taught something, and the uses to which we can be put are being thought out and considered.

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Now, if I can, I should like to enlarge on this matter and explain to those who have not thought out the subject some of the many ways in which we should be able to help for the common good.

To do this we will follow out an imaginary campaign. The war begins with a concentration at an oversea port or elsewhere, such as took place at Alexandria, for instance, after the bombardment of 1882. In this particular instance, the civil population had fled and there was no local skilled labour to be had. Now, on paper, a concentration at a well-found port seems simple, and, perhaps looking at it from outside, it is so, but it is an extraordinary fact, human nature perhaps, that no one ever seems satisfied with what he has got. The landing stages are not convenient for landing some particular kind of stores and must be altered; special landing stages are wanted for troops, so that stores and troops should not get mixed up; the departmental staff find excellent sheds to accommodate their stores, but the doors and openings are all wrong, railway sidings have to be brought up to them; water must be laid on to the enclosure selected by the veterinary officer for his remounts; the medical officer and headquarter clerks vie with one another in their urgent demands for shelving, the one for his bottles and the other for his stationery. Believe me, the unfortunate R.E. get inundated with requisitions of all sorts; some of the greatest importance, other only of importance because of the high quarters from which they originate; an active A.D.C. is sometimes a terror in these matters.

Now, in the early stages, just at the rush of things the only R.E. landed are probably the field companies and the only source from which tradesmen would be forthcoming to tackle these innumerable jobs. I want to tell you all this, because I have heard it stated that skilled tradesmen are not required in a field company, that a less expensive individual would suffice. Well, I may be prejudiced, but when I look up my journals and realize what calls were made on our tradesmen whenever a force was halted, either at the landing stage, on the line of march, or on the occupation of an enemy's town, such as Cairo, I am appalled with the thought of how blue the atmosphere would have been had tradesmen not existed. Even in the occupation of a friendly town it is wonderful how little accommodating the town seems to be, and how particular G.O.C.'s and C.O.'s become. But it is so natural that all these requisitions should be met, that no one waits to enquire what they entail to the R.E., and then they consist of such a multitude of small, though essential, services of which no record is kept, that no wonder when official histories are written no mention is made of them. I do not mean that we want this recognition, but what I wish to point out is the fact that when we are told that we do not want tradesmen, we find it difficult to prove the necessity to those who have not had the experience of what is expected of us in these matters.

Well then, from what I have told you, I hope you will admit we want tradesmen and that you will agree that a nominal 150 in a company is none too many.

Now married men amongst you who are not in occupation of Government quarters and have to pay for their own repairs will no doubt remember their economical spirit getting a shock when it is a case of repair, a simple

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burst pipe for instance, the plumber with at least two assistants turning up for the job. Well, I am not prepared to say that both assistants are absolutely necessary, but certainly one is, and you bless your stars in thinking that after all he or they are only labourers and therefore cheap. So you will readily understand that it is not economical to use any of these 150 skilled tradesmen as assistants, for assistant's work unskilled labour is the cheapest, and the more there is of this within reason, the more skilled work you will get out of your 150 sappers.

Perhaps some of you have guessed what I am leading up to; it is, of course, the necessity for working parties. So when you are halted at the base, on the line of march, or elsewhere, where there is work to be done, let us have what labour you can spare ungrudgingly, because what work is done, is done for you, not for ourselves. In foreign conscript armies, you know there are pioneer battalions, these I have always understood to be a self-contained units, *i.e.*, a units consisting of the necessary skilled tradesmen plus necessary unskilled labour. Until we have our own labour tacked on to our field companies like this, I feel we shall be obliged to borrow. In Egypt and South Africa we were allowed to hire natives, and in this way formed little pioneer battalions for ourselves, but that was exceptional.

Up to now I have been assuming that the army is more or less at rest, when the field companies would not, perhaps, be so closely associated with their divisions, but would, perhaps, be concentrated for, what I call, war works services, such services as I have mentioned above and those under the following six headings, which will probably appear in our new training manual, viz.:—

(1). The improvement of the piers, wharfs, derricks, pier and wharf accommodation, exits from the docks, etc.

(2). The provision of suitable entraining accommodation.

(3). The improvement and making of roads in the docks and town, and the marking of the routes to camps and depôts.

(4). The provision of water supply and sanitary services for billets and camps.

(5). The conversion of such buildings as may be required into hospitals, stores, sick lines for animals.

(6). The erection and maintainance of suitable telegraphic or telephonic communication.

Plenty of work you see for the engineer companies and their tradesmen.

But the army is now to move; each division must draw in its engineers and move off complete, the engineer work at the base being left to the line of communication troops. The march begins, in the early stages out of reach of the enemy, when the principal duty for the field engineer will be that common to everyone else, viz.:—to do the marches with the minimum of fatigue to men and horses, and it will much assist in this if, at the end of the day's march, the force can go straight into a fully prepared billeting area or other accommodation.

In small ways there is a good deal to be done before a billeting area, camping, or bivouac ground can be said to be prepared. Water supply arrangements have to be looked into; the municipal authorities can often

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help a good deal in this matter if given time and treated with tact and consideration; then there are always gaps to be made through hedges and walls, gateways to be enlarged, swampy places to be improved, etc.; so you see if you want to find everything comfortable for you when you march in, I would advise you to keep in touch with the C.R.E. and get him to make an early reconnaissance with your staff officer, and, above all, get your field companies on the ground and at work as early as possible; if the enemy is not in close proximity, it might often help to send on a field company well in advance of the column, so as to be on the spot several hours before the troops arrive with the engineer officers, employed on reconnaissance, well in front of these again, so that they may meet the company with a detailed scheme and lose no time in getting the R.E. to work. I want here to impress upon you all the *supreme* importance of engineer reconnaissance; if you think a little, you will see how much depends on this. Before you can commence work, you must first know what you have got to do. You have to get the necessary tools and materials on the spot, think out the best way to do the work, the number of men required to do it, etc., and all this takes time, and unless the problem is cut and dried by the time the workmen arrive, there will be waste of time and much cussing and swearing, marching and countermarching before the particular tradesmen with the particular tools and materials they require meet one another at the desired spot. If you want us to do good work, you must help us to look ahead; the more we can do this, the more efficient you will find us. You must give us the very earliest intimation. This seems common-sense, but yet, strange to say, there are occasions when this has not been given, and we have been expected to get work done as if we had a magician's wand at our disposal.

Engineer reconnaissance takes many forms. In my opinion, and I hope it will be clearly laid down in our new training manual, engineer officers should always accompany the general staff reconnaissance of a position or of a river or pass, or one made preparatory to a march or for the purpose of selecting billets, camps, etc. The duty of the engineer officer will be to study the best method in which engineers may be employed, so as to enable the commander of the engineers to advise on technical matters. It is important that reports, giving the details of engineering work required, should be sent from the cavalry to the army in rear, from the advanced guard to the main body, and from the army to the lines of communication. It is only by the early receipt of such information that the engineers with each portion of the force will be able to carry out the necessary work efficiently and promptly.

I remember not so very long ago at a staff ride, or divisional manœuvre, it being a question of the passage of a river, staff officers were sent out to reconnoitre suitable places to cross. When these came in, the engineer officer was informed that he was to make bridges at the places specified. He had then to make his own technical reconnaissance, and, at least at one place, found the technical difficulties so great that the general staff officer had to go out again and find another place. I merely mention this to show how much time is really saved by the staff taking an engineer officer with them on this sort of reconnaissance.

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Then there are reconnaissances in attack and defence. I will again quote them from what I hope may appear in our training manual shortly to be issued :—

"Prior to, and during, an attack, the attention of the engineers should be specially directed towards such points as will facilitate the advance of the other arms. Reconnaissances will, therefore, be carried out with a view to ascertaining what obstacles will be met with, and how they can be crossed or destroyed, what improvements in communications and approaches are necessary, the work required to strengthen covering positions, and the best arrangement of telegraphic or other means of communication."

So you see there is a good deal in this matter of reconnaissance for the engineer officer, and I trust that those responsible for training will see to it that we do not neglect this important work.

On manœuvres, etc., it is one of my duties to watch the work of the engineers. When I meet a field company, my usual remark is "Well what are you doing?" and I am sorry to say that the usual answer is "Oh, the usual thing, nothing ; we have got no orders." I am afraid that I then get angry and want to know why there are five engineer officers on the roadside doing nothing. I want to know why the officers are not ahead looking out to see whether they cannot do some useful work. If there is nothing better for them to do, they could with advantage visit farms, sheds, etc., and see whether there is barbed wire and what tools can be got in case these are wanted later. And here I may remind you that an engineer company carries only some 108 pickaxes and each infantry battalion only some 155 pickaxes, rather more shovels in each case; no materials, such as barbed wire or timber, are carried. So you see if entrenching is to be seriously taken in hand, it will be necessary to collect more picks and shovels from elsewhere, not to mention wire for entanglements and timber for overhead cover, and for these the engineer officer or others must search.

Well, we are now beginning to approach the enemy; you know it, because you find marching not so simple, the enemy is trying to delay you with obstructions, broken bridges, etc If your cavalry is in front of you, and the engineer officers with the field troops accompanying it have done their duty, they will have sent back precise details of the nature of the obstructions, broken bridges, etc., which would enable the C.R.E. to make his plans and get to work as soon as *you* get him to the spot. His men have to march remember, and if they are far behind in the column you will have difficulty in getting them to the front and, when you have done so the men will have had a forced march, so to speak, and you will not get such good work out of them than as if they had been with the advanced guard. Incidentally, I might mention that some French authorities make a great point of relieving the sapper of as much weight as possible when on the march so that he may be fresh to undertake work when required. My own view is that during the march the greater part, if not all, of your engineers should be with the advanced guard, but, in every case, please take your C.R.E. into your confidence before your operation orders are got out and make him responsible for the distribution of his units. He should know best what men and tools are required for the job

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in hand. R.E. field companies are small units and take up but little road space, particularly if the pontoons are relegated to the 2nd line transport, where they would usually be unless there is a prospect of having to bridge a river; if there is work for the engineers, it will be in front and usually, until the engineers have done their work, the column will not be able to advance. It is so easy to get your engineers off the road and out of the way if they are at the front and not wanted there, but it is quite another thing to get them quickly to the front from the rear.

We will now imagine that you have got your sappers to the broken bridge and are fuming to see it repaired. On manœuvres these things are simple, a piece of wood is put over the supposed gap and after a specified time the bridge is judged by the umpires to be repaired. This is a bad lesson. Bridges are not so easily repaired, for remember the spirit may be willing but the material absent; nice mast-like fir trees do not always grow on the spot. I suppose generally it would come to ripping up a floor of some neighbouring houses, which might be a little way off. And this is a point I want to make. Earlier in this lecture I asked you to help us with labour, and now I want you to realize that we shall often require transport also. Material will have to be brought in from a distance, planks and joists for bridge repairing, barbed wire, tools, etc., when putting a position in a state of defence, so do not grudge transport if we ask for it and you can spare it, it will be used in your interest.

You know, of course, that every field company has pontoons with it capable of bridging a 25-yard span to carry ordinary wheeled traffic, but it is not every river that is suitable for this class of bridge, there must be depth of water to float the pontoon for instance, and then it is not always advisable to tie up your pontoons so to speak, I mean use a pontoon bridge in preference to repairing a broken bridge, because the loss of your pontoons may be serious to you if there is a river to cross later when in touch with the enemy.

I am not certain that the tactical value of pontoons is always appreciated. Two years ago you know the manœuvres hung on the passage of the Thames. I had hoped to see pontoon bridges freely used and troops crossing at unforeseen places as a surprise to the enemy (a 25-yard bridge could have been thrown in some 15 to 20 minutes anywhere), instead of this, it seemed to me that commanding officers preferred to wait until the ordinary masonry bridge had been repaired, forgetting that its position was accurately known to the enemy, who in real warfare would have kept the defile well under artillery fire. Pontoons are horsed with six horses in war, so can go across country.

We are now in touch with the enemy, and the dispositions for attack are made, but not until after reconnaissance. On manœuvres this consists of counting red flags or observing lines of men on the slope of a hill supposed to be hidden away in invisible trenches. Now, of course, Gentlemen, you realize that the real thing is very different. I would just like to quote to you what they think of this abroad. Colonel Polyanski, in the February, 1909, number of the *Injenerni Jurnal*, says:—

"Reconnaissance or scouting in the attack is, properly speaking, a duty which belongs to cavalry, but such are the conditions of modern war, that

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it has become impossible for the cavalry to deal with all questions which have to be answered before the plan of attack can be decided upon. The modern arrangements for the fortification of a position are so complicated and reconnaissance is rendered so difficult by means of masking and the use of dummy works, that none but engineer specialists can understand from long distances the intention and character of the various fieldworks with which the enemy may have added to the strength of his position.

"That special engineer reconnaissance is necessary, first became evident during the Russo-Japanese War. In the month of September, 1904, when attack operations were in contemplation, it was decided to form engineer reconnaissance detachments, and these were recruited from among the officers of the engineer and sapper units."

This is a matter which hitherto has not been much studied. I must confess that I see difficulties under peace conditions, but I should like you to realize the necessity and try and train your engineers accordingly.

The reconnaissance having been made, the orders for attack are got out. At recent manœuvres it has been the practice to attach a field company to each of the leading brigades, but we must be careful not to adopt this as a hard and fast rule. Engineers must be distributed in accordance with their probable requirements, and I venture to think that in all cases the C.R.E. should be made responsible for that distribution after being made fully acquainted with the conditions, and that, even after distribution, the C.R.E. should still keep in touch with his command and, should circumstances change, advise a redistribution. For instance, the G.O.C. might suddenly decide during an action to have a position prepared to fall back upon, or a series of bridges might be required on a flank, in fact, anything might suddenly arise to make it necessary to withdraw the field companies from the brigades, so brigadiers should remember that at any moment they may be deprived of their engineers. Perhaps some might say "Well, I do not think that will matter much, for I do not see what use they can be to me in the attack." Unfortunately, manœuvres are not quite the real thing, or I venture to think those brigadiers would soon change their tune. Even on manœuvres I have seen a brigadier purple in the face because, through some mistake in orders, his field company had been left with the 2nd line transport; the brigadier had got into a village and would have given his eyes for engineers to make loopholes for him, blow down a few inconvenient walls, construct a few barricades, etc., but he had left them behind and got turned out of his village; and I was pleased, for it was a good lesson.

Gentlemen, even if you do not know what to do with your engineers, for goodness sake have them well to the front; you never know when you may want the gun-cotton and crowbars.

I know that in the stress of manœuvres, when everything goes about ten times as fast as it would in war, the unfortunate brigadier is kept at the end of his telephone and has little time to think of the accessories which do not count on manœuvres. I do not know whether you will think me right, but I tell our people it is their own fault if they do not get employed. It should be their business to help the brigadier, and they can best do this by keeping in touch with events. In my opinion, the major commanding

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the field company temporarily allotted to a brigade should be with the brigadier, and, of his four officers, at least two should be out to the front looking out opportunities for being useful; the artillery are hung up at a boggy place, a few planks and baulks would make all the difference; guns cannot get to an otherwise favourable position in a wood for want of a road being cut into it; the flank of the artillery position is much exposed, a suitable building exists there which, if put in a state of defence, would make for safety; the colonel of No. 1 Battalion sees his men hard pressed, he wants suitable rallying points formed, or a bridge blown up to stop the pursuit of the enemy, or a partially destroyed bridge repaired, to enable him to get up his ammunition and machine guns; obstacles removed; captured positions made strong, etc.; in fact, there are innumerable jobs, big and small, where the engineers can be of use. I hope that in our training manual about to be issued, the duties of the R.E. in the attack will be laid down as follows:—

(i.). Assisting the various arms to cross rivers, streams, difficult country, etc.
(ii.). Strengthening ground won, and special points, to help the resistance against a counter-attack, or to serve as pivots of manœuvre.
(iii.). The close reconnaissance of an occupied position.
(iv.). Removing or destroying obstacles prior to the final assault.
(v.). Improving and marking communications.
(vi.). The erection of observatories.
(vii.). Water supply.
(viii.). Fighting when required.

But again let me remind you that unless these things are practiced in peace, they will not be carried out intuitively in war. We want to be so much in touch with you, that you should get all these aids to your advance without your having to ask for them, so to speak.

Perhaps I might here be allowed to make a few remarks as to brigade training. I am sorry to say that I am not myself intimately acquainted with the routine of brigade training, but I imagine that you practice the attack and defence, and that in most cases some R.E. are put at the disposal of the brigadier. Since on manœuvres a field company is almost always attached to each leading brigade, we may assume that the practice will be carried out in war. Brigadiers should remember this and realize that the field company may often be a part of his command. He will then see the advantage of training it and his infantry brigade as one homogeneous whole. We have practically given up moving our field companies from station to station; so far as I understand the policy, the 5th and 11th (Field) Companies will always belong to the 2nd Division, so you see this homogeneous training I dream of can be made a reality, because the officers, non-commissioned officers and men of the R.E. are the same that will be with the brigade on the battlefield, and it is obvious what a pull the brigadier will have by knowing engineer officers personally and so training them to his ways that they will act intuitively on the battlefield. For brigade training, unless bridges or defences are to be actually

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constructed, it is, in my opinion unnecessary to take out the rank and file, since these can be better employed keeping up the knowledge of their trades in workshops than in marching about doing nothing; but all officers, non-commissioned officers, and tool carts, accompanied by a few sappers, should go out and, in the attack and defence or retreat, the brigadiers should make it their business to think how the R.E. can serve them and issue orders accordingly, just as they would in actual warfare. The R.E. can then make all their dispositions, get the necessary tools on the spot, arrange for collecting material, appeal for working parties, in fact, do everything except the actual work, and the actual work is an easy matter when a good preliminary plan has been made and tools, material, and *personnel* collected.

I feel certain that in real warfare, during the attack for instance, a brigadier will have calculated in his mind the chances of a temporary set-back due to counter-attack, etc., and, therefore, the need of rallying points. But this is only one of the innumerable ways in which he can get assistance, and the more he thinks out the problem and uses his imagination from an active service point of view, I am certain he will more and more realize the extreme importance of practicing these matters in peace. Even when he has no use for the men, he should remember that there are six more or less intelligent officers with each field company, each with a horse, and all dying to be his slaves in reconnaissance work, orderly work, or what not.

I shall deal with the defence later, but I have often thought that, when it is a question of a marked enemy, you have an excellent way of instilling into your engineers your ideas as to how to defend a position, and in this way would gain confidence in their work should the time ever come when you have to trust them to take up and strengthen a position for you in your rear for you to fall back on or otherwise. I suggest to divisional generals that they might give us a chance, now and then, to show our prowess in strengthening a position, by allowing us to work out the marked part, and we might even add a little "cunning" and means to deceive, which would add interest. At company training, when fieldworks are being done, I suggest that an officer from the field companies should meet the infantry company officers, and that they discuss the question of the siting of trenches, and their arrangement for mutual support, the siting of obstacles, etc., etc.

Well, so much for the attack.

The defence should, of course, be to the glory of the engineer. But I am not certain that we have yet arrived at the proper way to use him. Perhaps we do not sufficiently discriminate between a deliberately entrenched position, and position which a force takes up in the course of a battle and where the men dig themselves in, more or less, where they happen to be, and more to get cover whilst resting or organizing for a further advance, than with a view of standing their ground on the position, wearing out the attackers and then going for them and finishing them off in a good counter-attack.

In the former there can be but little science; in the latter there should be a very great deal.

In watching manœuvres, I have observed that it is often the practice to

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break up a field company into sections (you know a field company consists of four sections, each of some 33 men, 1 tool cart, 1 forage cart, and 1 pack) and distribute these all along the line. Now, personally, I do not think this an altogether sound arrangement. For manœuvre purposes it may be convenient, because you will not have the Inspector of R.E. telling the Inspector-General that the R.E. are not employed, but it is a slovenly, sealed-pattern way of doing things, which does not appeal to me. My view is that, if the field companies are allotted to brigades in the front line, the brigadier should take his O.C. Field Company to look over the position, and then decide what is the important work to do. There will be communications to be made in rear, to enable reserves to be gradually brought up, rallying points strengthened, bridges in the front constructed to admit of the further advance, clearances and roads to admit of the artillery getting to good positions, topping distant trees, etc., etc. So I consider that field companies should be held together until it is decided what work there is for them, and not broken up and distributed all along the position on the chance of there being something for them to do.

The course of events may make it desirable to fight an offensive-defensive battle on the position, by which I mean, as I said before, to allow the enemy to wear himself out against the position, and then go for him with all you are worth, to swallow him up in a great counter-attack. For this I venture to think a more scientific arrangement can be made than that of merely improving the trenches formed by the troops, when they dug themselves in with a view to further advance. More care must now be taken to co-ordinate work and add those accessories so essential to a properly defined position. Judging from what I have seen, I am sure that much more care should be taken in co-ordinating work than has usually been the case. I have seen one battalion commander take the top of the crest, whilst his neighbour took the bottom of the slopes. I have seen trenches from neighbouring sections arranged so as to fire into one another, but I have not often seen one section commander arrange his trenches so as to support his neighbour. For proper co-ordination you want a well-thought-out plan, and I believe it will be well worth your while to cause a roughly contoured map of the position to be made, showing approximately the arrangement of your trenches, etc. Given a 1″ map, it is astonishing how quickly they can be enlarged to a bigger scale, and with, say, four officers good at sketching, and a mile of front to do between them, viz., 440 yards each, a sufficiently accurate map on a large scale would soon be ready, sufficiently accurate for arranging a co-ordinated scheme of defence.

You see I have in my mind a position so scientifically defended that a minimum number of men are required for the defence, allowing of a maximum for the knock-down blow, the counter-stroke, and this cannot be done in a haphazard, happy-go-lucky way. But I am perhaps wandering from my subject, for it is the employment of the R.E. that we are discussing. Well, in this deliberate defence, as in all others, I think you should take your senior engineer officer into your confidence, and after explaining the position to him, allow him to make his proposals to you for this apportionment of work between the R.E. and the infantry.

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Now as regards the employment of your R.E. when strengthening a position, there is nothing laid down, and rightly so, because we are prepared to undertake anything, or should be, but, generally speaking, I should say that the officer commanding the section would decide where his fire trenches are to be, and so co-ordinate them as to mutually support one another and neighbouring sections; he would leave their construction entirely to the infantry, who, of course, should be equally competent to dig trenches, and better qualified for siting them. Only let me remind you that a battalion commander may site his trenches well from his own selfish point of view, but these very same trenches may, on the other hand, be exceedingly badly sited from the general point of view. I mean he must co-ordinate. Of course we may have many, many views on the siting of trenches. I remember coming across a trench, not so very long ago, beautifully sited for fire over ground from 800 to 1,200 yards from the trench, but a hopeless position for bringing fire to bear on the ground within 300 yards of the trench. The officer who constructed it said that regulations insisted on a good field of fire, and as it was a question of siting so as to bring fire over all ground within 400 yards of the trench, with a bad field of fire beyond this, or siting so as to get a good field of fire beyond the 400 yards, and much dead ground within this zone, he preferred the latter. Now I may be wrong, but I believe that that trench should have been sited so as to bring every bit of ground within 300 yards of the trench under fire, leaving the ground beyond to be got at by cross-fire from neighbouring trenches if possible. It is sometimes forgotten that when you are occupying a crest exposed to the enemy's artillery fire, your heads may be kept under by it until the attackers are within 200 yards of you, so that the very extended field of fire is not always so important as would first appear to be the case. To my mind the important thing is that every bit of ground from the trench as far as possible outwards should be under fire from the trench or flanking trenches; that even at the sacrifice of field of fire the trench should be hidden from the enemy's artillery fire, that command, as a rule, takes too high a place in the scale of importance, that it must be borne in mind that where trenches are placed low down on a slope, it is difficult for the enemy's artillery to support the infantry attacks; with the trenches at the top of the slope this support can be given up to the last moment. With trenches low down, almost at the bottom of the slope, it is easy to hide them, and double line of fire, combined with dummy trenches, becomes possible. The argument against the low-down trench is the difficulty of support, but there is no difficulty in constructing trenches for the supports on either side of the firing trenches. We have got into the habit of digging our trenches for support well behind the firing trench. I cannot understand the reason. They should be close up to the firing trench, and so save communicating trenches.

Then there is the question of retreat; but we do not fight to retreat. Besides, there are nearly always little subsidiary valleys running in at right angles to the main features which can be easily screened to admit of retirements. Of course, there is the other alternative of making your trenches well back from the crest, holding the crest with a few men to

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bring fire on lines of approach and mislead the enemy by means of dummy trenches, and flanking the advanced slope with artillery fire, which can often be arranged in a fairly low position. The above, of course, are only my opinions, and they are certainly against practice, for we seem always to get in well-exposed positions half-way down a slope, or on the crest. The fact is, there is this instinct, which it is so difficult to get away from of being able to see everything from our trenches. Foreign authorities lay stress on the importance of short trenches, not more than 40 yards long, as these can be more easily arranged for mutual support and invisibility than long lines of trenches. For protecting the flanks, they prefer trenches in echelon.

So much for siting trenches. Well, Gentlemen, this is your job, and not that of the R.E., except when forced to do it, as when they are sent to entrench a position on their own, which it will, by the way, often fall to their lot to do, with the assistance of working parties, civilians, Territorials, Special Reservists, and others. No, the infantry should dig their trenches, and I think you will be well advised to employ your engineers on the accessories in laying traps for the attacker, putting cunning and science into the defence, etc. The section commander should, in my opinion, explain to his O.C. R.E. the general scheme of defence, and ask him to suggest the accessories. There are clearings to be made, dummy trenches, and artificial screens to be constructed, entanglements and obstacles cunningly arranged so as to force the attack to come over ground to suit you, dead ground filled in, trees topped which would otherwise block artillery fire, bridges in front of the position destroyed, walls loopholed, communications in the rear constructed, head cover and casemates, in fact, there are a hundred and one things to be thought of beyond the mere entrenchments, and often these are more important than the trenches themselves. Unfortunately, manœuvres do not admit of the use of these accessories being developed, and I fear that in consequence we are not giving them the attention we should do. It would be interesting if some day at divisional training a marked position were specially prepared to admit of these accessories being employed with all the cunning and deceit that the art of the engineers could devise. You would have to employ special devices to show entanglements, clearing obstacles, dummy trenches, etc., but this would not be difficult.

I expect the attack of such a position would give some fun.

I remember not so long ago a flagged position had been carelessly marked (at least this was the excuse). Two of the red flags had got out of place well to the front of the main line. It was a foggy day. Those few flags completely misled the attack, and it was a long time before the real position was grasped.

I feel we have yet much to learn in this matter of deceiving the enemy.

Now, Gentlemen, before concluding, I should just like to read you a few notes on some foreign ideas on taking up and strengthening a position. It is interesting to know what line others appear to be taking, it provides food for thought.

Well, some of the foreign authorities propose to hold the main line of a position by means of fortified localities or *points d'appui*, occupying

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those tactical points which the attackers must seize before being able to make further advance.

These *points d'appui* are to be at supporting distance each from the other and arranged, if possible, so as to flank one another.

They are either fortified natural localities, such as woods or villages, or are artificially constructed.

Each is given a definite garrison, which provides its advanced posts, supports, and reserves. The duty of this garrison is to hold on to the ground to the last. The duty of the reserve is to turn out the enemy should he affect an entry into the locality, or deliver offensive returns, and go for his flank should he penetrate the interval between the *point d'appui*, or support a neighbouring *point d'appui* should it be hard pressed. In fact, the reserve of each *point d'appui* is, as I understand it, a mobile force for action inside and between *points d'appui* in what is called the "return offensive," but not for action beyond them. The remainder of the garrison allotted to the *point d'appui* is an immobile force strictly on the defensive. The rest of the force provides the grand reserve, which is the mobile manœuvre force from the great counter-attack by which alone a victory can be obtained.

A few entrenchments are sometimes of advantage, constructed in the intervals between *points d'appui* to help the reserves of the garrison of the *point d'appui*, or local mobile force in its duty, but these should not be occupied except when the offensive return is being made. The *rôle* of the artillery, presumably inferior to the attackers, is chiefly to bring cross fire in front of the *point d'appui* and support the counter-attack. It is said that this arrangement admits of the fewest possible numbers of the defenders being immobilized by occupying trenches, because they appear to consider that troops manning entrenchments are practically immobilized as regards offensive action, and leaves the greater number free for mobile action, and that these can be kept under cover and resting until the moment arrives for that mobile action. It is also said that by this arrangement the attacker is gradually worn out, that he has to expose his hand and that of the commander, by keeping in communication with the various *points d'appui*, can, as it were, feel the pulse of the attack, and so know where and when to launch his counter-attack, by which alone decisive results can be obtained.

Naturally, these *points d'appui*, whether natural or artificial, must be made very strong, with ample cover for supports close up to, and connected with, the fire trenches. A keep should be provided—something solid and storm proof—to enable some portion of the defenders to hold on till help can be sent, even were the trenches rushed in a night attack, for instance.

Some authorities point out that it is the business of the commander of the *point d'appui* to try and get the attackers to go for him, and not to deter him from doing so by long distance fire, etc., because the mere fact of a serious attack being made means that a force of four or five times that of the garrison is being employed, and so a greater number of the enemy is being immobilized than in the defence; whereas, if the commander, by showing his strength, prematurely frightens off the attacker,

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it means only that the enemy's forces, which would otherwise have been committed and so immobilized, will go to swell the attackers elsewhere.

The attacking artillery, firing on a *point d'appui* at long range, cannot be said to be immobilized, because it has the power of diverting its fire to neighbouring *points d'appui*; it can only be said to be immobilized when it is not in its power to do this, that is to say, when it has been obliged by circumstance to come in so close so that all change of objective becomes impossible, or that the infantry that it is supporting requires its undivided attention.

The attacking infantry can only bring pressure on a *point d'appui* by being sufficiently close to it, but this attacking infantry cannot necessarily be said to be immobilized, because up to a certain point it is at liberty to break off the attack.

So you see a *point d'appui* is liable to a distant artillery attack, and may have to resist an infantry attack without the pleasure of knowing that the attackers are really committed and, therefore, immobilized as regards actions on other parts of the battlefield, and the commander is not to be congratulated when, by his energetic action, he has warded off an attack.

A *point d'appui*, then, to fulfil its mission, must be ready to receive shot and shell and bullets without replying, and must, therefore, be well organized for defence.

Some authorities believe in taking up the main line of defence some distance behind the main advance crest, that is to say, on a secondary crest, or even on the reverse slope, if not steep. They point out that if on the main crest, which is fully exposed to the enemy's artillery fire, your infantry are subjected for a long time to the nerve-shattering effect of an artillery bombardment, and are forced to keep their heads down until the attackers are within 200 yards of the position, when supports cannot reach them without elaborate arrangements in the way of covered communications, whereas if the front crest is occupied by a few well-placed detachments, in trenches, with dummy trenches in between, the power of the rapid smokeless fire of the modern rifle will allow of the enemy being deceived, and he will probably deploy for attack and carry the crest. Once this done, you have them at a disadvantage, because you can sweep these crests and the intervening ground with your artillery, when he cannot use his artillery, and the conditions for counter-attack become very favourable.

Well, Gentlemen, these are some foreign ideas; there are many more. There will always be many opinions on this difficult subject. There can be no hard and fast rule for taking up and strengthening a position, but, undoubtedly, you will enormously handicap your adversary if you can manage to take up a position which is not an obvious one to him and not defended in an obvious way to him. If you can do this, you may deceive, confuse, and delay him, and sometimes so manage as to prevent him making effective use of one of his arms, such as his artillery, and at the same time retain full scope for your own, and so bring about all the conditions for a successful counter-attack.

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REVIEW.

GEOLOGY FOR ENGINEERS.

By Lieut.-Colonel R. F. Sorsbie, R.E.—(Griffin & Co.).

The relation of geology to every branch of civil engineering, almost without exception, is so obvious as to require no explanation, yet, so wide and varied are the other sciences which must be studied in connection with the equipment of the modern engineer that this fascinating and important branch of learning is either neglected or at most confined to a few lectures, usually far above the head of the ordinary student. There is, however, a certain amount of excuse for this neglect in that the study usually involves the reading of a large number of textbooks containing matter which, though of great scientific value, is of little relevant importance to the practical engineer. It also involves outdoor examination of rocks and their characteristic positions which cannot be carried out except under expert guidance. Lieut.-Colonel Sorsbie has in this book given the cream of a large number of scientific treatises in so far as they relate to the profession of the civil engineer, and has supplemented this information with many valuable hints as to what to observe in the field, and how to make observations.

In carrying out this task, which from the very nature of the case has involved much labour and careful selection of relevant matter, he has worked on a definite plan. He has divided his work into five distinct parts.

Part I. treats of Dynamical and Structural Geology, giving emphasis to the various agencies which have effected changes on the earth's surface, *e.g.* the work of wind and of rain, of underground water, and rivers, of glacial action, of ocean waves, and of living organisms. Then follow changes within the earth, internal forces, volcanoes, crust movements, earthquakes. Subsequently three sections deal with the structural characters of rocks of various classifications, igneous, aqueous and metamorphic. The whole of this part is a valuable foundation for the more detailed parts which follow.

Part II. deals with the study of Minerals, touching first on the subject of mineral chemistry, mineral forms, and the physical character of minerals. Then follows a chapter on rock-forming minerals, their classification and a fairly exhaustive list of various sorts. The study of rocks naturally follows giving indications as to their mode of origin, their composition, structure and physical characters, and finally a chapter describing the

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more important rocks in such a way that they may be distinguished by the observer. The order of description follows the structural classification in Part I.

Part III. deals with Historical Geology, classifying the rocks of the earth's crust in order of their formation, and pointing out the successive groups of living creatures that have made their appearance at various epochs. The tables which form part of this section of the work refer not only to the sedimentary strata in Great Britain, but to the chief groups in North America, in Australia, and New Zealand. There are numerous illustrations of the fossils to be found in the various strata, In the description of the geologic systems there are references to nearly every part of the world, showing the main characters of the earth's crust in each place.

These three parts of the book occupy half the volume—a modest 188 pages full of close compact writing. The only criticism which we have to offer in this portion is that the writer might have alluded to the value of the various geological and mineralogical museums to be found in most places in supplementing the printed page. Without some actual examples of the various minerals and fossils, it is difficult to grasp clearly the distinction between the many and varied rocks described.

The remainder of the book is devoted to geological observation, in the field and in the laboratory, and to the applications of geology to practical engineering. In this portion of the book the author addresses himself to those who are acquainted with the ordinary phraseology of engineering, it is not necessary, for instance, to explain what is meant by a contour, or how to use a clinometer. The hints on fieldwork are sound and practical. Some of the purely technical definitions, however, *e.g.* those referring to "strike" and "dip," are a little wanting in clearness, a few illustrations here would have assisted in elucidating matters. There is a slight error in page 198 where "sin A" should read "cosec A." While making these criticisms it is fully admitted that they only refer to minor details, the main instructions are most ample, and well arranged. The indoor work in the laboratory would obviously be out of the reach of most practical engineers, probably time would be saved, and inaccuracy avoided if the specimens collected were sent for analysis to a chemist or Government analyst.

Part V. occupies one-third of the book and is rightly devoted to considering the bearing of geology on various branches of engineering, water supply, building materials (stones, bricks and clays, limes and cements), roads and canals, the action of rivers, coast erosion, and the uses of minerals. This is a very valuable section. What numbers of humiliating failures have occurred, what vast sums of money have been wasted, owing to the want of precautions based on sound geological knowledge and its practical application. Any engineer who has had to carry out works of any magnitude is well aware of this, and the necessity of such knowledge is accentuated when such works have to be executed in countries out of the range of civilization. The author has evidently borne this fact in mind, for his observations deal with fundamental principles and range over wide areas.

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Lieut.-Colonel Sorsbie is to be congratulated on having placed within the reach of all a book of very moderate size, full of definite and accurate scientific teaching. The library that the practical engineer carries with him, necessarily limited to a few trusted guides, is the richer for the addition of this book. It is not indeed a royal road to learning, nor can it dispense with the laborious and determined study of the subject out of doors. But it serves its purpose if it guides towards that study, and, as far as we can judge, its guidance is reliable.

Officers of Royal Engineers, who have to undertake works in all parts of the British Empire under every variety of condition and climate, will find this book a very sound guide in many of the problems which they have to solve. This is especially the case with those who have to construct mountain roads, or to work out water supply schemes, two of the commonest tasks that devolve on military engineers, and in both of which cases success largely depends on accurate knowledge of geology.

G. K. Scott-Moncrieff.

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NOTICE OF MAGAZINE.

RIVISTA DI ARTIGLIERIA E GENIO.

March, 1911.

MODERN PERMANENT FORTIFICATION AND LESSONS TO BE DERIVED FROM THE SIEGE OF PORT ARTHUR.—In a valuable work lately published by Colonel Jacofleff, military engineer and professor at the Nicolas Academy, important facts are brought to light with regard to the methods of siege warfare. Extracts from this work are taken from the supplement of the *Internationale Revue über die gesamten Armeen und Flotten* for November, 1910.

The author sets out with a consideration of the strife that commences at the moment when the besieger enters on the zone of infantry fire or about 500 to 600 metres from the work. From this point it is necessary for the attack to proceed by means of the sap, and successive positions of the infantry, until the assaulting position is established at about 200 metres from the work.

Before Port Arthur however the Japanese were able to approach nearer, for instance before Fort II., the sixth position of their infantry was found at 40 paces from the brow of the glacis, but this was only possible because the ground permitted of it and the works were deficient in any essential means of defence.

Jacofleff divides the near attack into three phases, commencing from the instant at which the assailants occupied the last infantry position, *i.e.*:—

1st. The attack on the glacis.

2nd. The attack on the ditch.

3rd. The attack on the ramparts and interior of the work.

Attack on the Glacis.—According to the theory of Vauban, this attack which constitutes one of the most difficult for the besiegers should be commenced openly, and recourse should only be made to underground operations when absolutely necessary. Its phases were calculated by weeks, and in fact they lasted all the time that a regular attack was carried on for the assault of a fortress.

Arab-Tabia in 1854, Strasburg and Belfort in 1870, the redoubts of Griwitza in 1877, the unfortunate assault of Perche before Belfort, and the attack of Geoktepe in 1882, are eloquent examples in the face of which a rapid attack according to the theory of Brunner, Sauer and Scheibert cannot be entertained. The Japanese, who found this theory convenient and opportune at Port Arthur, knew how much it would cost them and found it their duty to decide upon a regular attack which had

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been at first excluded: however before the final decision they tried a new assault and were able to capture the glacis. This success might constitute an argument in favour of a rapid attack; but the question assumes another aspect when one considers the losses attendant and also (1) Under what circumstances the assault may succeed, and (2) By what technical and tactical means the attack on the glacis may be prolonged.

With regard to the first point it is necessary to note :—

(*a*). In front of the intermediate work No. 3 the Japanese on the 20th September had commenced the work of the sap, starting from the first redoubt, and it was not until a month later that they were able to capture a trench which the Russians had excavated at 400 paces in front of the counterscarp. The Japanese utilized this trench against the enemy and setting out from this on the 20th October carried on the work in advance. The Russians had planned a system of mines but were unable to carry this out owing to a want of the necessary tools and material; the fougasses organized as mines of observation were rendered unserviceable from losses produced by the enemy's fire which had broken the conductors and exploded the cartridges; so that there only remained the barbed wire, incomplete and insufficient even for a fieldwork, and which presented no difficulty to the destructive work of the Japanese pioneers. The artillery fire was also insufficient to sweep the ground around the intermediate works. The throwing of bombs by mechanical apparatus was imperfect, and could only be used to a limited extent against the Japanese approaches.

The defenders were reduced as a last resource to making sorties to resist the enemy's attacks. But these sorties were rare, and only diminished the capabilities of an active defence; the garrison was weak and unfitted for undertakings of this kind; the observations of the ground at night could not be properly maintained. These failures, it is said, resulted in placing the Japanese in possession of the glacis.

(*b*). In front of Fort No. III. there was a large dead angle which it had not been possible to avoid during the construction of the defensive works, but the defects of which it was sought to remedy by the construction of an advanced trench, provided with numerous blindages. The Japanese arrived on the 26th October at 20 paces from this trench and took it by assault after having silenced the defenders with a formidable artillery fire. They united it with their last infantry positions by means of trenches of communication and from thence they turned their approaches against the fort. The pioneers arrived at the foot of the counterscarp wall, and commenced to excavate rifle pits without encountering any opposition.

(*c*). In front of Fort II. there was a dead angle at the foot of the glacis which the Russians had given up defending, contenting themselves with constructing an obstacle of barbed wire which was under the fire of the fortress and flanked by the neighbouring works. At this dead angle, in the middle of October, the Japanese organized undisturbed their last infantry position, and excavated a mining gallery under the glacis. But this work was discovered from a work in the vicinity, and the Russians then tried to obstruct the work by sorties and countermines.

Owing to the Russians having exploded a charge of too great strength, a funnel was produced which laid open a portion of the counterscarp wall.

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The besiegers at once profited by this accident and occupied the funnel and commenced the crowning of the glacis.

Returning then to the first point of the question, it may be concluded that the short period that the defence lasted before the crowning of the glacis, was due to defects in the construction of three permanent works of importance, and to an insufficient supply of artillery ammunition and pioneers' tools, and also to technical and tactical errors on the part of the defenders.

The most efficacious means of preventing the enemy from occupying the glacis would be a system of well-organized countermines. The galleries should be of sufficient length and so arranged that the enemy cannot reach the flanking defences. At Port Arthur the mines were excavated by men who had not been properly instructed and who worked with tools ill adapted for their purpose, so that their efforts were like the last convulsive spasms of a dying man.

It is most important for the defenders to utilize their obstacles, and every means possible for prolonging the defence.

If the besiegers construct galleries in advance, the defenders should endeavour by every means in their power to impede the execution of the underground works, by artillery fire, throwing of explosives, sorties, etc.

At Port Arthur the defenders are said to have used Whitehead torpedoes containing 31.5 k.g. of guncotton thrown by means of marine torpedo tubes, and charges of 6 k.g. of guncotton belonging to the guns of 47 m.m. thrown by means of a pole. But such primitive methods are bound to fail, and it may be found necessary to construct special apparatus for throwing explosives at short distances (from 30 to 250 m.).

For observation services a covered way with recovering places for sentries and blockhouses for the relieving guards are necessary, and it is indispensable that these observation posts should be in communication with the commandant by means of the telephone. During the night there should be a service of electric searchlights of large aperture installed on the flanking batteries, and also movable searchlights and torches in the covered ways.

But notwithstanding all these measures the enemy's intentions and work can only be ascertained by means of sorties made with small detachments, judiciously led, accompanied by pioneers, miners, artificers who should throw themselves against the advanced infantry position. And, as it may be suggested that this is almost a forlorn hope, these sorties should be used parsimoniously and after mature reflection on their duties and the moment and method of their execution, taking care to keep the secret up to the last moment and using signals which should not attract the attention of either side.

It is impossible to predict the time that the underground warfare will continue, or who will gain the victory. At the commencement the advantage should be on the side of the defenders, if they have been previously prepared in peace times by serious and complete exercises.

E. T. THACKERAY.

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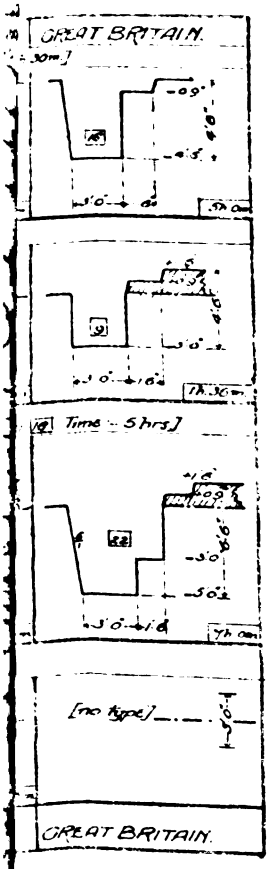

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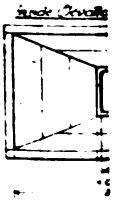

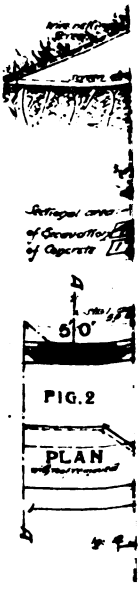

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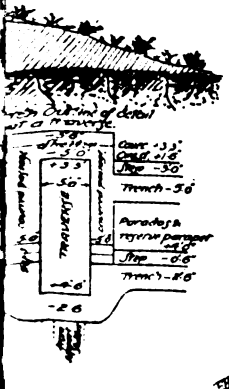

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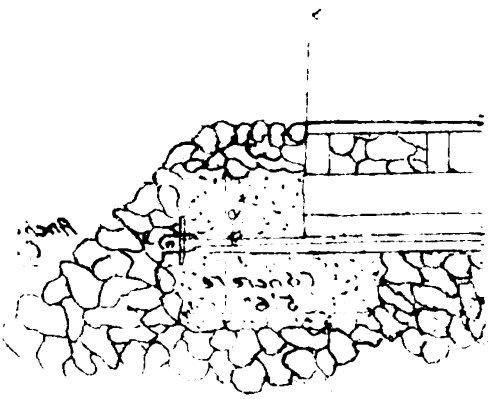

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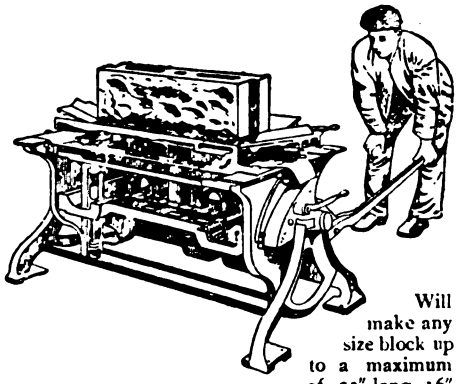

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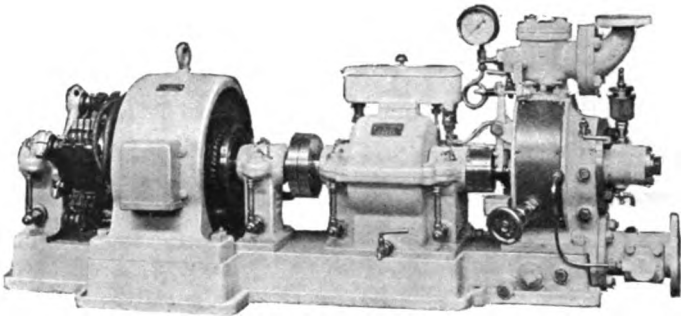

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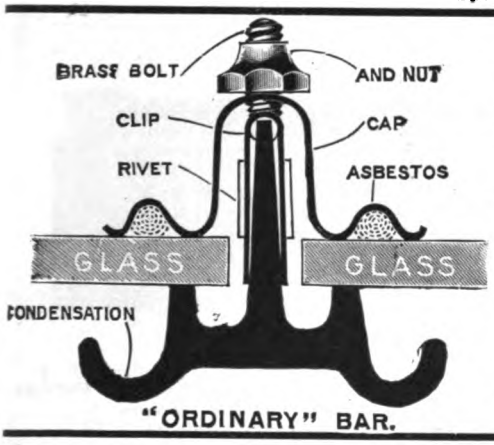

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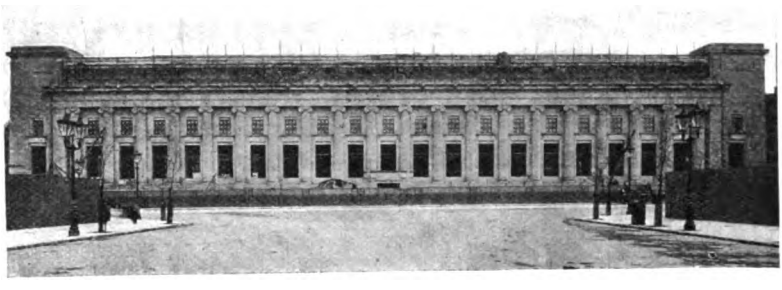

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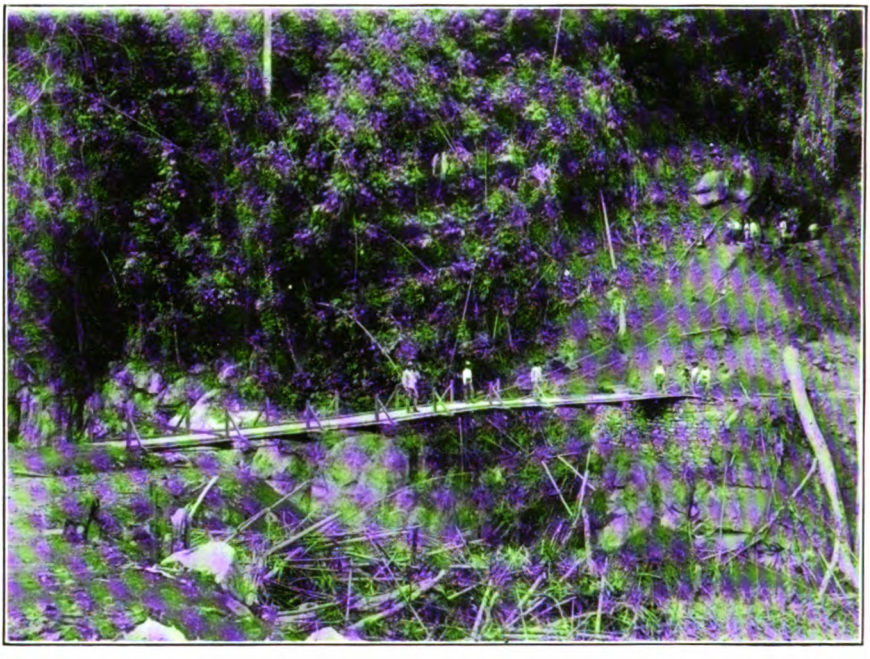

Photo 3.—Narzar Kha Bridge, 105′ span.
"Single Ender."

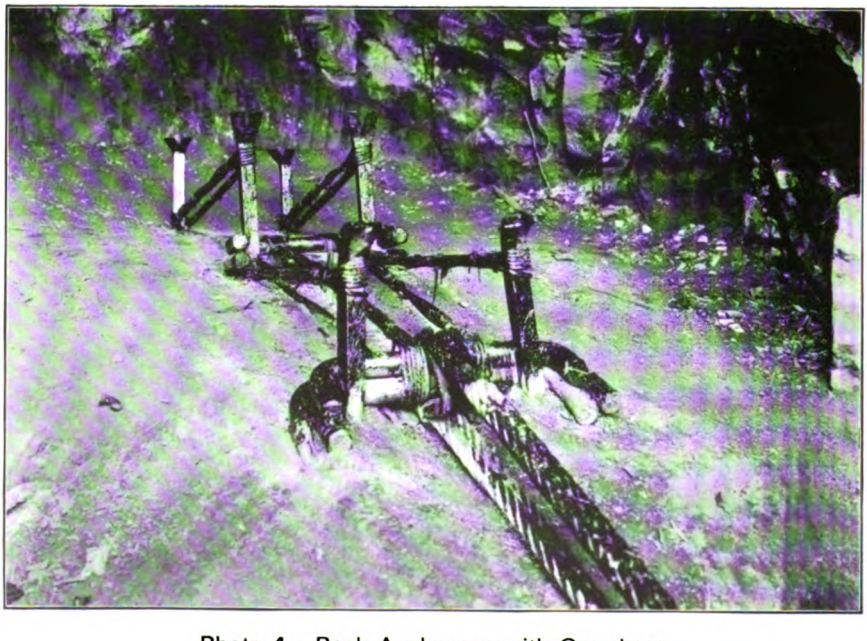

Photo 4.—Rock Anchorage with Crowbars.
Showing one end of one Suspension Cable.

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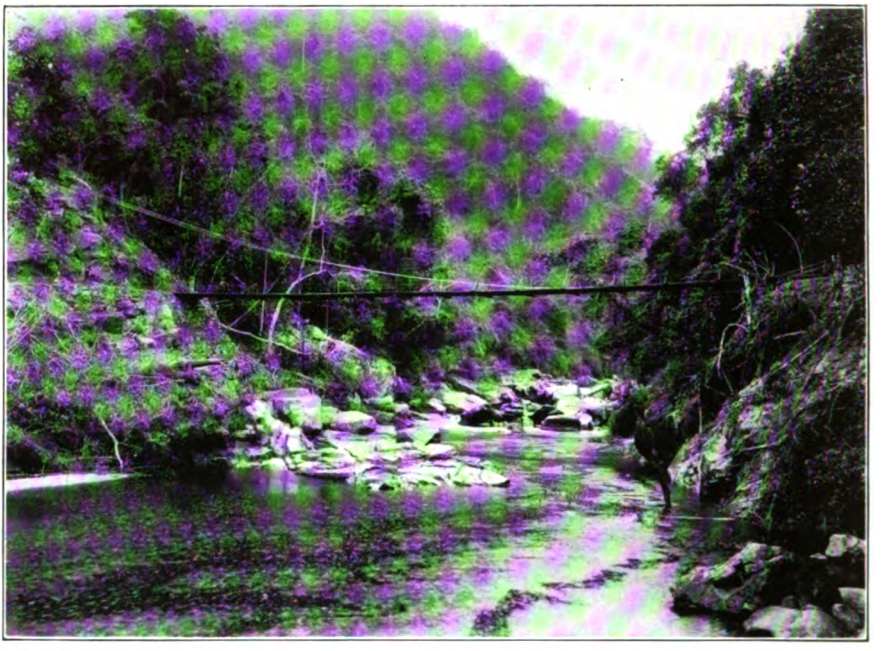

Photo 1.—Ta Mu Kha Bridge, 160′ span.
"Single Ender."

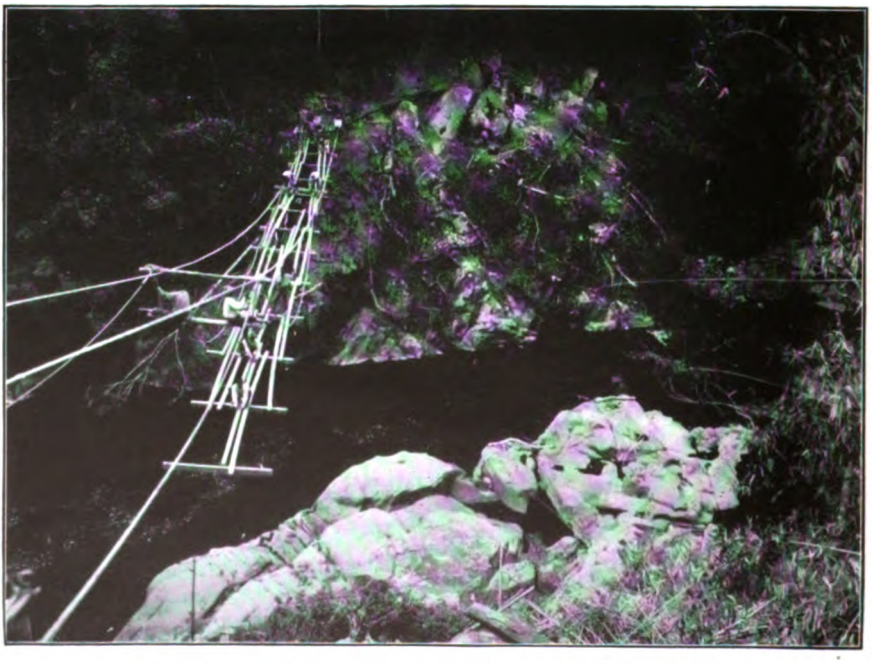

Photo 2.—Ta Mu Kha Bridge under construction.

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BRIDGING WITH THE BURMA SAPPERS.

By Bt. Major R. L. McClintock, d.s.o., R.E.

In the autumn of 1910 a force of about 400 Military Police, supported by a regiment of native infantry, was despatched to investigate and provide an "effective occupation" of the district of Hpimaw, an inconsiderable Kachin village near the Burmo-Chinese frontier, some 140 miles north-east of Myitkyina (see *Plate* I.). The latter had previously been entirely unadministered, and very rarely visited by a European.

With the advanced guard, which left for Hpimaw about the end of November, went Lieut. Harris, R.E., and 25 rank and file of the Burma Sappers and Miners.

With the adventures of this "Hpimaw Column" it is not my business to treat, but the village in question having eventually been reached and occupied by it, the authorities finally decided to withdraw the force again to Myitkyina, leaving a police post at a place called Ruckchong in the vicinity.

To maintain communication with this post during the rains, which are both early and torrential in these Kachin hills, it became necessary to provide a road. The native track by which the column had laboriously advanced to Hpimaw had proved very difficult for transport as it ran direct from crest to crest of the successive mountain ranges, sometimes at gradients of 1 in 4, and as the surface was mainly clay it became totally impassable in wet weather.

Accordingly in January, 1911, the Burma P.W.D. was called upon to construct a good 7′ wide mule track with a ruling gradient of 1 in 15, from Myitkyina to the new post. This track was to follow the valley of the N'maikha River, thus skirting round the worst of the hills. The river in question is the larger of the two streams which, uniting some miles north of Myitkyina, form the Irrawaddy, and even in the dry season is a furious, unfordable, unnavigable torrent. The country through which it tears its way is nothing but a succession of steep mountain spurs covered with dense bush, running more or less parallel to each other down to the N'maikha. Those who have served in West Africa and on the North-West Frontier can best picture it by imagining the bush of the middle Niger transplanted

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on to the khuds of Waziristan. The jungle is so thick that it is impossible to camp without first clearing a patch of ground, and the slopes so steep that it is usually also necessary to level a site for each tent.

As the mountain spurs abutting on the N'maikha alternate with tributaries feeding it, the latter had to be bridged to give passage to the new road. The local native (the Kachin, a wild but harmless race of diminutive stature) is uncommonly good at the erection of temporary bamboo bridges over these streams which serve well enough in the dry season, and by these the column had moved out. The rains, however, had to be taken into account, and in the rains these rivers rise 20′ or 30′ in a few hours, and become raging torrents whirling along forest trees and rolling down boulders as large as houses in their wild career. For the purpose of this bridging work the services of the remainder of the Burma S. and M. were placed at the disposal of the P.W.D.

As the whole of the operations connected with Hpimaw were being conducted by the Civil Government and not by the military authorities, the Government of India would not sanction the S. and M. going on ordinary field service conditions (*i.e.* all their expenses being debited to military grants) but had recourse to a system peculiar to India, in which a company of S. and M. is "permitted" to take up work for a private employer or another Government department. This system, briefly, is that the military authorities cut the S. and M. Company the working pay of the men (and make certain other disallowances affecting both the rank and file and the officers) while the O.C. of the unit has to make a bargain with his employer—be it private firm, Government railways, P.W.D., etc., etc.—to secure such terms as will at least ensure his men against loss in the transaction. If he can in addition make a little profit, it usually is devoted to giving the rank and file a trifle extra working pay.

This system is usually an excellent one as it provides most useful technical training of all sorts for the men combined with a saving to military funds, but for its success it is essential that the O.C. should be allowed a perfectly free hand in making his bargain with his civil employer. In certain cases, however, when the work is of an urgent and semi-military nature, he is apt to find himself strongly urged by his military superiors to lose no time in getting to work, while his prospective departmental employer (being naturally anxious to get the services of the S. and M. as cheaply as possible) exhibits a certain coyness about coming to what the O.C. considers fair terms. Such was the present case, and considerable correspondence took place before the P.W.D. agreed to such conditions as the O.C. considered would place all ranks in the same financial position as if the work had been an ordinary field service job. The position of an O.C. between the Scylla of appearing to

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delay or shirk useful and urgent work, and the Charybdis of letting his unit in for a heavy pecuniary loss is neither a pleasant nor a dignified one.

However, satisfactory terms having at length been conceded by their civil employers, the company at the strength of 1 British and 3 native officers, 2 British sergeants and 100 rank and file, left Mandalay on the 15th February and arrived at Tumpang Kha on the 24th of the same month. This was about the furthest point of the then administered territory, and all the bridging work lay in front.

It was already late in the year to begin so large a work, as the rains were reported to be due about the 10th May, after which no work is possible owing to the excessively malarious nature of the jungles, and also to the extreme difficulty of moving about the country. Considerable delay in getting to work was, however, experienced at this point, as not only was the actual alignment of the road still unsettled, but all tools and material for the bridges had yet to be obtained from Rangoon. Also, the column had absorbed practically the whole of the available transport of the district, and there was very little means of moving the Sappers and their rations to the site of their work. Fortunately the alignment was decided on shortly after the arrival of the S. and M. at Tumpang Kha, so that the actual earthwork of the trace could be put in hand, but the lack of tools and material, to say nothing of transport, delayed the commencement of the big bridges for nearly three weeks more.

The distribution of the work between the P.W.D. and the S. and M., arranged during this halt at Tumpang Kha, was briefly as follows. The P.W.D. was to carry out all the earthwork of the new trace with coolie labour, and to undertake all minor bridges of 60′ clear span and under. There is an excellent standard type girder (made of wood and wire cable) employed by the P.W.D. in the Myitkyina district which will cover spans up to 60′, but has not so far been adapted to anything greater. The S. and M. were consequently allotted the job of all bridges in excess of 60′ clear span. There were four of these, the Ta Mu, Hnawmaw, Ritney and Narzar Khas. In addition there were three much larger rivers, the Tumpang, Shingaw and Chipwé Khas, which it was decided were too big to be tackled this year. To negotiate these "flying ferries" were employed, made from 3″ wire cable stretched high above the flood, and sustaining a raft of two large "dug-out" boats bearing a platform. The S. and M. took part only in the construction of that at Tumpang Kha.

During this enforced wait the Sappers did not remain idle but executed a quantity of minor bridging work, constructed the dug-outs for the Tumpang Kha ferry, and supervised and assisted the

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huge gangs of P.W.D. coolies, now rapidly accumulating and representing almost every race from Pathans to Chinese, employed on the earthwork of the new road trace.

Lieut. Harris and his 25 men rejoined headquarters from the front on 8th March, bringing the strength up to 2 British and 3 native officers, 2 British sergeants, and 125 rank and file.

It was not until 14th March—a month after leaving Mandalay—that the O.C. was enabled to move with the right-half company to the site of the first big bridge, the Ta Mu Kha (*Photos* 1 and 2), and begin preparing the anchorages for a suspension bridge of 160′ roadway span. The steel cables for this bridge arrived on elephants on 3rd April, and the bridge was finally completed on the 14th idem.

In the meantime Lieut. Harris and the left-half company had been able to move on past them to the Hnawmaw Kha (suspension, 152′ span) and had arrived there on 1st April.

On completion of the Ta Mu Kha bridge, the right-half company had moved past them again on the 15th April to the Narzar Kha (suspension 105′ span, *Photo* 3) and having finished this by 2nd May, moved back again to undertake the Ritney Kha, a suspension bridge of similar span. As the left-half company was just at that moment at a standstill for want of woodwork, the bulk of the company was able to concentrate on the Ritney bridge, completing it by the 9th May, the Hnawmaw bridge also coming to an end the following day. As these four suspension bridges completed the special task assigned to the S. and M., the left-half company started down country at once. The work had only just been finished in time, as between their departure and that of the right-half company, delayed about a week for want of transport, the rains actually commenced, rendering the six days' march to Myitkyina anything but a pleasant experience. The malarious reputation of the district also received full justification, as, on return to Mandalay, practically the whole company—European and native—went down with fever of the malignant Tertian type.

The company had thus completed four suspension bridges of between 100′ and 200′ span between 14th March and 10th May (57 days), besides having executed a large amount of general bridging and road work prior to the former date.

This output of work may not seem very great to those who are accustomed to operations on the fieldworks ground, where it is only necessary to send across to the store to obtain anything required from a chess to a 3″ cable. In the jungle, however, where not only had approaches to be dug and huge stone abutments to be erected for the shore ends of each bridge, but where every solitary roadbearer and chess required in its construction had to be sawn from a tree felled on the spot, and where not even a nail was procurable within a week's march, things perforce moved more slowly.

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The natural difficulties, too, were considerable. The banks of the rivers at the bridge sites sloped as a rule from 30° to 45° and were covered with dense bush, which had to be completely cleared before the site could even be finally chosen. Forcing one's way through such bush, in which every member of the vegetable world seems armed with fish-hook or spear, and in which every insect stings or bites, is by no means pleasant work. So venomous, in fact, were the flies that a large percentage of the daily sick roll was contributed by men suffering from severe ulcers caused by fly-bite, and the sensation of getting a handful of red tree-ants down the neck is one that will linger "while memory holds her seat." I may here remark that the working dress of the company had hitherto been "shorts," but these were found quite unsuitable for wear in such a fly country, and the men were glad to cut the arms off their jerseys and make a sort of mitten out of them to protect their bare knees.

The steep slopes of the banks were greatly to our advantage in that they enabled us to dispense entirely with artificial piers for all the suspension bridges and anchor the cables directly to the banks at a suitable height instead. On the other hand, levelling a sufficient plateau for an anchorage (and place for the men to stand to work, for which at least 15′ × 20′ is required) on such slopes, usually meant shifting over 2,000 cubic feet of earth for each end of the bridge. Nor were the banks as a rule either of sound rock, in which crowbar anchorages could be used, or of good earth easy to get out for the log pattern of anchorage. Normally they were found to be either a compost of boulders bedded in clay, or a mass of soft disintegrating granite, too full of fissures to blast, but extremely troublesome to chip out with the pick. As a result, more than half the time taken over each bridge went in the preparation of the anchorages.

The main cause of delay, however, was the fact that all the transoms, roadbearers and chesses had to be made at site from trees felled and cut up by the company sawyers. Owing to the system of "taungya" cultivation in use by the Kachins (which briefly consists in felling and burning a portion of the jungle every year, the whole being dealt with once in about fifteen years) although bush was only too plentiful, good trees suitable for the saw-pit were scarce, and the scantlings had often to be carried over a mile from the pit to their destination. The company could only muster enough sawyers to run five saws at once and the services of some civilian sawyers had to be called in to lend a hand with the roadway of the Hnawmaw bridge.

Technical Notes on the Work.

1. *Type of Bridge Employed.*

Three out of the four suspension bridges were made on the "half-loop," or as we were wont to call it, the "single-ender" principle.

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This system lends itself specially to cases where the banks are so steep that it is possible to dispense entirely with artificial piers by anchoring the cables direct to the slopes at a suitable height for the dip and span.

As a "single-ender" is calculated as being half a "double-ender" (*i.e.* ordinary pattern with two piers) of twice the span, it will be evident that for any particular bridge the height of the single pier will be double the height of the piers of a "double-ender." Consequently, if the piers are dispensed with and bank anchorages used instead, the anchorage of the "single-ender" will be twice as high up the bank as that for a double-ender would be. Consequently, also, it will be proportionately further back from the shore end of the bridge. Thus there will be considerably more room for the road to reach the shore end of the bridge without dangerously undercutting the anchorage up above it in the bank. Of course an alternative to cutting the road out of the slope is to bring it up to the bridge on a stone abutment built up against the edge of the gap, but this is always tedious, and, in the case of deep gaps, impracticable.

To take an example (*vide Figs.* 1 and 2) suppose a gap of 120′, a dip of 1 in 10, and the banks to slope at 45°.

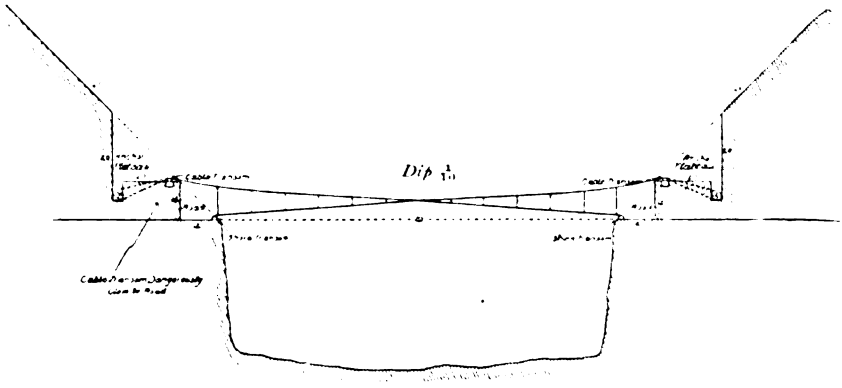

FIG. 1.—"*Double Ender*" *Suspension Bank Anchored. Earth Banks.*

If a double-ender is constructed, each "anchor plateau" will come 12′ above the horizontal, and its cutting line next the bridge will be 12′ back from the edge of the gap. If a roadway 12′ wide has to be taken to the shore end of the bridge by cutting back into the slope, the back wall of this road will (even if left vertical) come directly beneath this cutting line. This means that the "cable transom" must either be taken still further back (which means very greatly extending the cut of the "anchor plateau"), or be put almost over the top of the back wall of the road, which is a very unsafe position, as the pressure of the cables on the "cable transom" naturally tends to break down this wall.

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If, however, the bridge was constructed as a "single-ender," the anchor plateau at the high end comes 24′ above the horizontal, and consequently 24′ back from the edge of the gap. Thus the inner cutting line of the anchor plateau comes 12′ back from the back wall of the road, instead of just over the top of it, a much safer position for the cable transom.

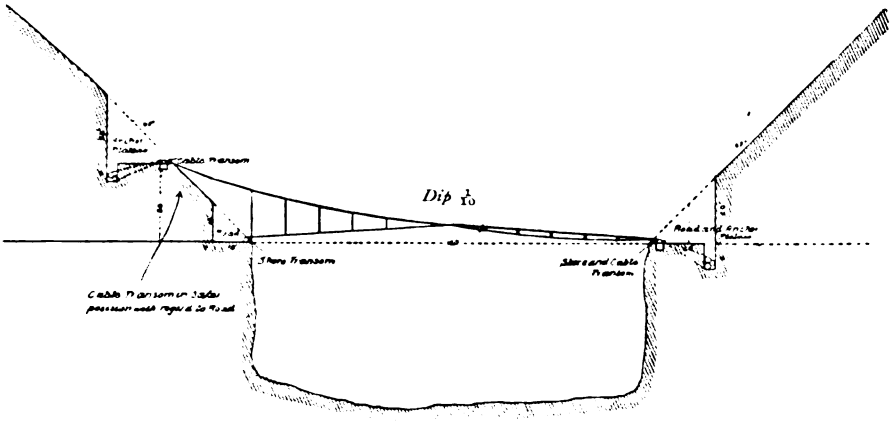

FIG. 2.—"*Single Ender*" *Suspension Bank Anchored. Earth Banks.*

As regards the anchor plateau at the "low" end of the bridge there is also a saving, as the one excavation does duty both for the road and for the anchor plateau.

2. *Modification of Calculations due to Unloaded Spans.*

Owing to the sloping banks, the span between anchorages (that is, span between imaginary pier heads) was always greater than the actual roadway span. In the case of the Hnawmaw bridge these were 230′ and 152′ respectively. This meant that about four bays at each end of the bridge remained unloaded. As the loaded portion naturally took a lower position in these circumstances than it would have done had the whole cable been uniformly loaded, this upset the ordinary calculations for the sling lengths considerably. However, a method of calculation was evolved which gave the correction in the case of a "double-ender" with an equal number of unloaded spans at each end. The question of a "single-ender" with three or four spans at the "high" end unloaded was more complex, and, though a graphic solution was finally evolved which gave approximate results, the slings at that end usually required adjustment to bring them the correct length.

This is a point which requires attention in these bank-anchored bridges.

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3. *Anchorages.*

Two sorts only were employed: crowbar anchorages when sound rock could be found, and the ordinary buried log anchorage when it was a case of soft rock or earth.

Of the latter variety I have nothing to say, except that it was unfortunate that they were unavoidable, owing to their lack of permanency. I am informed by the local P.W.D. that in the Kachin Hills wood rots so quickly underground that a couple of years is all the life that can be expected from any bridge thus constructed. Logs of reinforced concrete and bundles of short lengths of railway metals were both considered as alternatives, but proved equally impracticable for want of transport to fetch the cement or rails to site.

As regards crowbar anchorages, I attach a sketch (*Plate* II.) and a photograph (*Photo* 4) of the type found by experience to be most suitable. I may remark that the *Manual of Military Engineering*, Vol. III., does not supply a very great deal of information on this most important subject. From *M.M.E.*, *Plate* I., *Fig.* 7, and para. 32, it might be imagined that two crowbars, of 1" diameter placed one behind the other, are sufficient for any stress which a 3" wire cable will stand. In my experience this is not the case. I believe the anchorage as above illustrated is just about strong enough for a 200' bridge devised for loaded pack animals.

In conclusion I may remark that in the course of the four bridges the company erected about 11,725 cubic feet of dry stone abutments and excavated some 17,400 cubic feet of earth and rock, besides undertaking a good deal of blasting to assist the road work coolies.

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GIRDER BRIDGES FOR MILITARY ENGINEERS.

By Capt. E. N. Mozley, R.E.

PART I.

CRITICISM AND RECOMMENDATIONS.

A. General Considerations.

1. *Reasons for Infrequent Use.*—It is not often that the girder bridge or truss is used by military engineers. The chief reasons for this neglect have probably been the following :—

(*a*). The limitation of span over which girders can be used, and the fact that gaps of a kind for which neither trestle nor floating bridges are possible do not often occur in nature.

(*b*). Alleged complexity of design, calculation and workmanship.

(*c*). Difficulty of launching.

These objections require consideration.

(*a*). *Limitation of Span.*—As regards the first :—It may at once be said that where intermediate foundations can be made use of, either on land or water, no types of bridge, other than those carried on trestles or floating piers, would be adopted. And thus we are at once confined to a small minority of sites for which a single span type is suitable. Then again, for spans over 100′ the suspension bridge is alone possible in the field, as timber bridges over a single span are practically confined to that limit in war time, and the extensive use of iron, essential in long spans, is possible for the soldier only in the form of suspension cables.

Another cause which limits girders to 100′ is this :—The least proportion of depth to span in a girder to ensure reasonable stiffness may be taken as 1 14. Now the depth of field girders cannot much exceed 7′, the limit of reach of a man standing ; if any greater depth is attempted it is a matter of inordinate difficulty to raise the girders from the ground into a vertical plane and keep the top flanges from distorting. Finally girders longer than 100′ become very heavy, and the preparations for launching are so extensive that the chief advantage of these bridges, viz. their secrecy and the speed of that part of their construction which is in view of the enemy, is lost.

(*b*). *Complexity of Design.*—The first objection is therefore conceded. But the second is less reasonable. No engineer should be

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alarmed at the prospect of having to design and calculate a girder, and, moreover, if these bridges were more frequently practised, standard types would be chosen, the soundness of design of which had been tested by the experience of others. Nor is there any real reason to hesitate on account of the careful workmanship involved. It will be found that the type of girder advocated in this article as the most serviceable, is analogous to the plate girder, and requires only nails for fastenings. Even the open truss patterns, requiring bolts and nuts or oak trenails at the panel points, need but little skilled labour, and an 88′ lattice girder bridge, of which a description is given below, was easily put together by untrained cadets under the superintendence of a R.E. N.C.O., whose trade was that of a painter.

It is no doubt the case that girder bridges require a great deal more care in the construction of the girders, than do cantilever or even suspension bridges at any stage of their erection. But the great argument in favour of girder bridges—*their speed of construction once the enemy can see where the crossing is to be attempted*—will generally allow plenty of time in building the girders, prior to bringing them up to the gap.

(*c*). *Difficulty of Launching.*—There remains the third objection—the difficulty of launching. This has perhaps been solved by the adoption of the suspension cable method of which an account is given below.

2. *Advantages of this Type of Bridge.*—The great advantage which the girder bridge possesses is secrecy. It alone of all bridges except those on floating piers can be built elsewhere than at the site it is to span; and therefore, although the *total* time of construction of a girder bridge at a given site is as great as that for other types, yet the time during which the work is under the view of a possible enemy is very much less than in any other single span bridge. It may be reduced to three hours or even less for a 90′ or 100′ span under favourable circumstances, where a cantilever, suspension, tension or frame bridge could not be built in less than 12 hours. This advantage may be of supreme importance when the crossing of a rapid river or deep gap, watched by the enemy, is to be attempted, and gives to this type of bridge a definite place in military engineering.

The other advantages of girder bridges are :—

(1). Steadiness and stiffness.

(2). Small size of material required.

(3). Independence of the ground at the site.

(4). That accurate workmanship under fire is not required.

As compared with suspension bridges, girder bridges are steadier, require no cables and little if any wire except for launching, and are independent of anchorages or of a careful adjustment on the site.

As compared with cantilever bridges they are steadier, require no such quantity of large timbers and are independent of anchorages.

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As compared with frame bridges they require no long spars, are independent of accurately cut footings and of accurate section taking and frame locking on the site. They are also suitable for longer spans.

It may be said at once that it is most difficult to build and launch girder bridges strong enough to carry infantry in fours or cavalry in half-sections, except for comparatively short spans, on account of their weight. It is better to build several light bridges close to each other for traffic such as cavalry in single file or perhaps infantry two deep, thus obtaining the undoubted advantage of not putting all your eggs into one basket and also saving much time in launching.

B. Descriptions of Bridges Constructed.

The writer's experience in building girder bridges includes the following examples :—

(1). A 51′ bridge to carry cavalry in single file.

(2). An 80′ „ „ infantry in fours. (This bridge included a central trestle and two different types of girders).

(3). A 49′ bridge to carry cavalry in single file. (Including 2 types).

(4). A 57′ „ „ „

(5). A 78′ „ „ „

(6). An 88′ „ „ „

A detailed description of these bridges is given in Part II. and a tabular statement of their details at the end of the article.

C. Type Recommended for General Use.

From an analysis of these bridges it is suggested that the best type of girder is the "plate," as in (3) and (5), (the bridge to consist of two separate girders joined before launching), and the best method of launching is by means of rollers and light suspension cables as in (6).

1. *Reasons for Choice.*—The plate type with the web secured to the flanges by long wire nails is preferred to open trusses for the following reasons :—

(*a*). Planks of small and even thickness are easier to obtain than those of larger and of various scantlings. The former are necessary for plate girders, the latter for open girders. Nails are easier to obtain than bolts and nuts (except on lines of communication or where forges are plentiful).

(*b*). Nails are safer than bolts and nuts, as is also a continuous series of planks than a truss, in each case on the principle that no single nail or plank in the plate girder will wreck the bridge if it fails, whereas in the open type, stresses are carried along chains of planks and bolts and the failure of a single plank or bolt may destroy the bridge. It is in fact the well-known superiority of riveted girders

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over pinned trusses. Good workmanship is therefore not so essential in the plate type.

(*c*). Plate girders are simpler and quicker to put together than open girders. A certain complexity surrounds the assembling of lattice or even Warren girders, and it is generally found that some forcing has to be employed to run the bolts or trenails through all the planks at a panel point.

(*d*). Nails are quicker and easier to work with than bolts and nuts, and thus time is saved and skilled labour rendered less necessary.

(*e*). In the plate type the weight of the bridge during launching can be reduced by omitting every alternate plank from the web. This cannot be done with open girders.

2. *Example.*—The following design for a 100′ girder bridge, which is probably the limit of span for this type, is given as a simple instance of the plate girder:—(*Fig.* 1 shows the cross section).

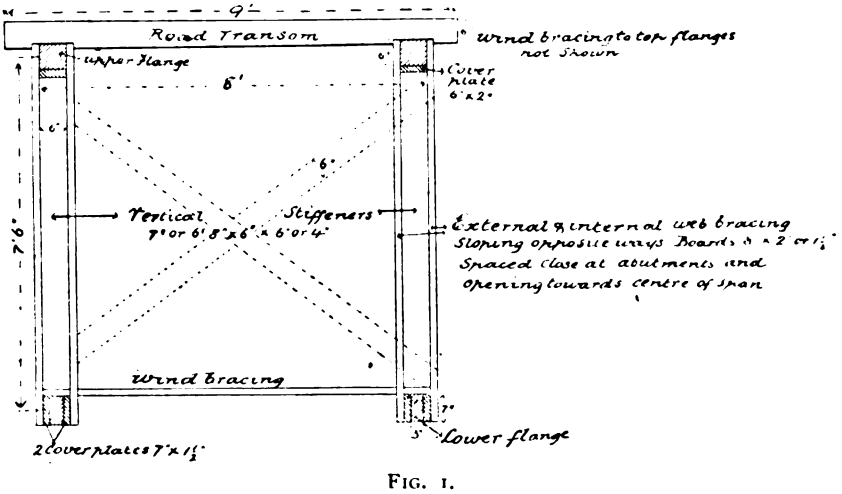

FIG. 1.

Bridge to carry cavalry in single file. Roadway 60 lbs. per foot-run.

Weight of both girders and wind bracing estimated at 12,000 lbs.

Roadway carried by two plate girders, 8′ centre to centre.

Depth of girders, 7′ 6″, centre to centre of flanges.

Maximum distributed load on one girder, $\frac{1}{2}(196\times\frac{3}{2}+60+120)100=23{,}700$ lbs.

Maximum safe stress of timber taken as 1,200 lbs. in compression and 2,000 lbs. in tension, per square inch.

$$MFF=\frac{WL}{8}=\frac{23{,}700\times 100}{8}=296250 \text{ foot-pounds}=Mr=rad$$

$$=\begin{cases} Compression\ flange\ 1200\times a\times 1.5. \\ Tension\ flange\ 2000\times a\times 1.5. \end{cases}$$

∴area of top flange must be 33 square inches.

„ of bottom flange must be 20 square inches.

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The depth of the timbers of the lower flange should be considerable to prevent them being crushed by handspikes while launching, and also in order that the web planks should not protrude below the lower flange.

Make the depth 7″ and the width 3″.

The upper flange should be square—say 6″ × 6″.

The lower flange will then be 3″ narrower than the upper flange; if the cover planks for the lower flange be 1½″ planks, placed at each side of the joints, and having a combined cross section equal to the flange, they will give to the flange a total width of 6″. (The cover plates should be continued the whole length of the lower flanges).

The cover plates of the upper flange will be placed above and below the joints and may be 6″ × 2″ planks 8′ long, extending 4′ each side of the joint.

Stiffeners.—Every 6′ along the girder will be placed a vertical 6″ × 6″ plank, perpendicular to the flanges and held in place by fillets as in *Fig.* 2. These stiffeners partially support the road transoms and should not therefore open out towards the centre as in iron bridges. The dimension parallel to the axis of the bridge could probably be reduced to 3″ or 4″.

The stiffeners will butt on the lower flange and on the upper flange, or its cover plates.

If the roadway is carried on the lower flanges, the end stiffeners may be 6″ × 6″. If it is carried on the upper flanges the ends of the girders must be shaped as in *Fig.* 3. In such cases the end web planks must be very stout.

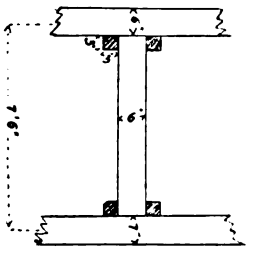

FIG. 2.

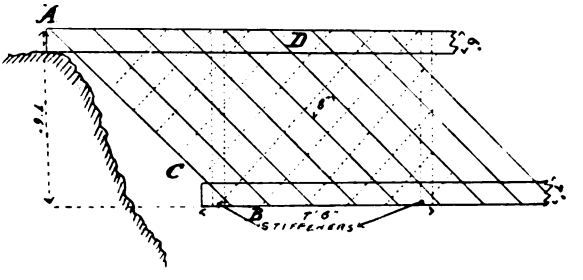

FIG. 3.

The shearing stress on each girder at the abutment, if a gun were close to that abutment and the rest of the bridge were crowded with cavalry, would be about 13,000 lbs., and, since the web is 7′ 6″ deep, the vertical and horizontal shearing stresses per foot-run are in each case 1,733 lbs. Now each girder is to have two systems of web planks (running diagonally at 45°, in opposite directions), each of which systems therefore sustains a horizontal shearing stress of 866 lbs. per foot-run. A 6″ wire nail, connecting a 1″ plank to a spar, draws at

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800 lbs.* Therefore if we use 8″ web planks and nail each end of each plank to the flange with three wire nails we shall have a factor of safety of about 3.

Web planks will be adjacent to each other at the abutments and will open out gradually to 3′ central intervals in the middle of the girder, in accordance with the decreasing shearing stresses.

Cover Plates between Parts of Lower Flange.—These have to transfer a stress, varying from 39,500 lbs. at the centre to about 25,000 lbs. at the joint nearest the abutment. There are three alternative methods of transferring this stress across the joints :—

(*a*). By means of a wire sling of the requisite number of returns passing through transverse auger holes 18″ from the joint, or preferably through several auger holes between 1 and 3′ from the joint on each side, since a single auger hole gets bitten into, if it has to carry the whole stress.

(*b*). The requisite number of large wire nails driven through each cover plate into the flange on both sides of the joint.

(*c*). The requisite number of bolts and nuts passing through auger holes bored through both cover plates and flange on both sides of the joint.

Any one of these methods involves a considerable amount of iron-work, *e.g.* the weight of nails or wire to transfer the stress across the centre joint of the lower flange of the girder under consideration would be 15 lbs. and 20 lbs. respectively.

The second method can only be employed if the timber is sound, as the large number of nails required is liable to split it.

The first method has the disadvantage that when the load comes on the bridge the wire stretches, the joints open a little and the bridge loses its camber.

The third method takes longest and bolts and nuts are not always obtainable.

The short cover plates to the joints of the top flanges may be nailed to the flanges.

The alignment of every top flange joint would be preserved by means of a hard wood dowel, placed in axial holes bored into the ends of the two butting timbers. The dowel should be a little shorter than the sum of the depths of the holes at the joint to allow the surfaces to touch.

Wind Bracing.—Top Flange.—In addition to the cross transoms (pieces 10′ × 6″ × 6″ at every panel point), there would be a series of horizontal diagonal bracing, placed lattice-wise, nailed to the top surfaces of the flanges. Planks 8″ × 1″ or 6″ × 1½″ may be used.

The bottom flanges would be temporarily braced together during launching by cross planks nailed to the flanges. Subsequently a

* From the writer's experiments.

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system of horizontal diagonal bracing similar to that of the upper flange would be nailed on above or below the lower flanges.

The road transoms would be notched across the flanges and spiked to them. They need not be fixed till the bridge is in site, if it is desired to save weight in launching.

Fig. 3 shows the diagonal web bracing on one side of a girder by continuous lines and that on the opposite side dotted. Vertical stiffeners also shown dotted.

The web must be doubled on both sides of each girder for a short distance from each abutment. *E.g.* :—In *Fig.* 3 there will be a series of planks parallel to AB on each side of each girder for perhaps 10′, the series parallel to CD being nailed in each case on the outside of the series parallel to AB. At the other end of the girders the position is of course reversed.

A system of transverse vertical diagonal bracing, from the top of each stiffener of one girder to the bottom of each stiffener of the other, and *vice versâ*, would be nailed in pairs at intervals along the length of the girder to prevent the bridge being racked or distorted during launching (shown dotted in *Fig.* 1).

D. Placing the Roadway on Girder Bridges.

Girder bridges have a great advantage over all others in that the roadway can be laid much more quickly. The top flanges of the girders supply a gangway along which the material can be carried. The road transoms are placed at panel points (or over the stiffeners in plate girders), *i.e.* from 6′ to 8′ apart. Each bay of roadway (transom to transom) will be made up under cover, the chesses being nailed to the roadbearers and the ribands to the chesses. If possible the roadway should be 2′ narrower than the central interval between the girders. Each complete bay will then be carried on to the bridge by four to eight men, who hold lashings underneath it and walk along the flanges, and will lay it in its place. If necessary the bays may be connected by nailing strips of wood from riband to riband on the outside. The whole operation (exclusive of putting the bays together under cover) should not take more than 10 or 15 minutes for a 90 or 100′ bridge if plenty of men are available. This is an important saving of time if under the enemy's observation and fire.

E. Possible Arrangement for Strengthening a Girder Bridge after Placing it in Position.

Fig. 4 represents a girder bridge of 90′ span. As soon as the bridge is across and the roadway laid, proceed as follows :—(The process here described is carried on simultaneously from each bank).

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Get two poles AB as long as possible (up to 35 or 40'), the diameter need not be very large. To the two tips B lash a cross-piece the tips being as far apart in the clear as the width of the bridge out to out. To each end of this cross-piece (outside of the pole AB) make fast a chain or wire (eventually CBD), doubled so that the bight hangs towards D and the two single ends towards C.

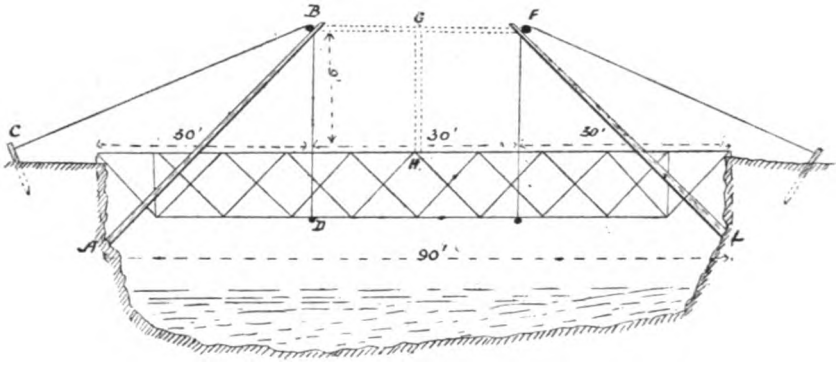

FIG. 4.

Carry this 3-pole frame on to the bridge. Lower the butts A until they get good seatings and then, by means of pike poles and the chains CB haul up the frame until AB is at a slope of not less than 45°. Make fast the bight of the chain at D round a previously placed cross-piece under the lower flanges. Make fast C to a hold-fast and windlass up CB and BD. If long enough material is available, B and F may be joined by planks or poles on each side (shown dotted in the figure) and braced to the girder at GH. Finally the poles AB should be lashed to the girders.

(*To be continued*).

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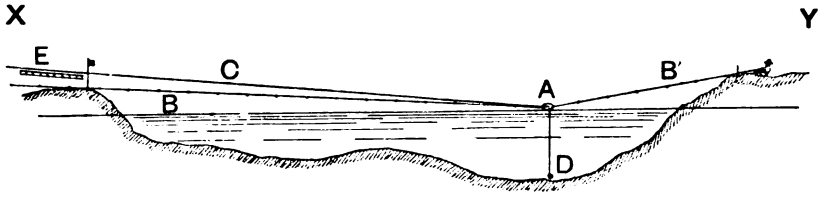
A SIMPLE APPARATUS FOR SOUNDING RIVERS AND PONDS OF MODERATE WIDTH.

By Brig.-Gen. C. Penrose, c.b., R.E.

The apparatus described below was used by the writer in New South Wales many years ago to sound, and take sections of, large public water tanks for sheep and stock in the "back-blocks" of the colony.

The apparatus acted so well and enabled the work to be done so quickly, that it is thought it might very likely be useful to officers who have to rapidly sound and get sections of moderate widths of water-way, even when boats are available.



A. Float.
BB′. Float Lines.
C. Sounding Line.
D. ,, Lead.
E. Measuring Staff or Tape.

Use.—Get one man across the water with line B′, by swimming or otherwise, from X to Y. Pass sounding line through float A on bank X and attach plummet.

Pay out line B and haul on B′ and take soundings every 5, 10 or 15′ getting width of stream at same time.

In taking the soundings haul the sounding line up smartly until the lead hits the float and then lower away sharply, measuring the amount let out with a rod marked in feet and inches. This can be done two or three times for each sounding very rapidly.

If the current is very rapid it will be necessary to hold the ends of the lines BB′ some distance upstream so as to get the float on the section line.

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The sounding line must be fine and run very easily through the hole in the float, and a heavier lead will be required in deep and rapid water.

The float lines BB' must of course be very well stretched before they are marked off and used.

The form and material of the float for rapid streams is probably of importance.

The sounding line should be kept on a fishing reel and be treated with the care given to a fishing line.

The distance from the surface of the water to bottom of plummet must be added to each sounding as recorded on the measuring rod, *unless* allowed for in marking the rod.

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A METHOD OF BUILDING SEA WALLS.

By Capt. T. E. Kelsall, R.E.

The following method of building a sea wall in shallow water is believed to be new. It was suggested by Staff-Sergt. Henry, R.E., M.F.W., and recently carried out successfully at Ragged Staff reclamation, Gibraltar.

A reinforced concrete retaining wall had to be built along the sea face of the reclamation. Owing to the presence of boring mussels, and also to ensure sound work, it was considered advisable to keep this reinforced work above low-water mark by building it on a foundation of solid concrete. This foundation had to be in 4′ to 5′ of water at low tide. At first concrete was deposited in the water behind sheeting, being tipped on to the bottom through a timber tube placed vertically in the water and reaching nearly to the bottom. It was hoped by this means to get the concrete to the bottom in sufficiently good condition to set properly, but the results were unsatisfactory.

The new method referred to was then adopted. It consisted in making concrete boxes and floating them to the required position, where they were sunk by filling with concrete.

The boxes were 10′ long, 5′ wide, and 4′ deep, with sides about 2″ thick. The first one made was not reinforced, but when floated, the water pressure broke in the bottom. Subsequent boxes therefore had the bottom reinforced with hoop iron off cement barrels, and these proved sufficiently strong. They were made in timber casings placed on an existing level surface, which at low tide was about 6″ above water level but at high tide was covered by about 3′ 6″ of water. A small hole left in the side of the box at floor level allowed the water to enter as the tide rose. Had this not been done the water outside would have forced its way through the unset concrete, which would have been spoilt. After two days the sheeting was removed, the hole plugged at low tide, and as the water rose the box floated.

The line of foundation was dredged to the required depth by means of a large toothed scoop, worked by a windlass from a staging. As the bottom consisted of stones of various sizes, a level bed had to be formed of an average depth of about 1′ by depositing concrete in bags. These were rammed from above water, their finished surface being about 4′ below low-water level.

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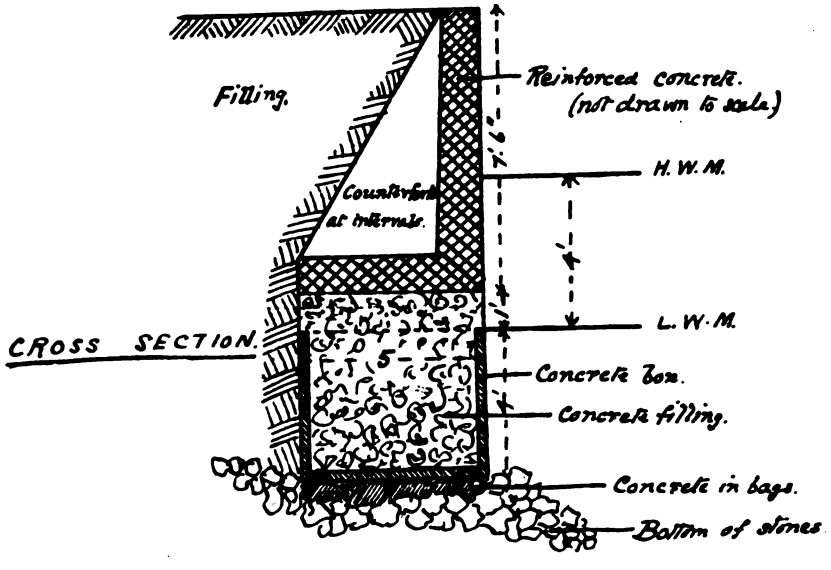
The boxes were then floated so as to lie with their length in the line of the wall, and each having been got into its correct position in plan, was sunk on to the level bed by filling with concrete. Sheeting having been erected, another foot of concrete was added on top at low tide.

The rough sketch below illustrates the method.



One box had a 2′ concrete pipe through it to form the outlet for a drain. This pipe was fixed after the box was made but before it was floated.

It is intended shortly to try an extension of the above method in connection with the uprights for a reinforced concrete pier in deeper water. The difficulties in this case will be considerably greater, and it will be interesting to see if they can be successfully overcome.

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THE BRITISH MILITARY MISSION IN EGYPT, 1798—1802.

(*Concluded*).

In the August number of the *R.E. Journal* certain instructions and letters were given, referring to the Military Mission in Egypt between the years 1798—1802. To these are now added Major Holloway's account of the Turkish operations from December, 1800, to their completion in July, 1801, and a report by Major Hope, R.A., on the Dardanelles, giving a detailed description of the fortifications in 1799.

(7).

Report of Lt.-Col. Holloway, R.E., on the Operations of the Supreme Vizier between the 3rd December, 1800, and the 16th July, 1801.

GRAND CAIRO, EGYPT,
1st August, 1801.

A concise Statement of the operations of His Highness Yanssouff Zia Pacha The Supreme Vizier, from the 3rd December, 1800, the time He received Information of a British Force being in the Mediterranean for the purpose of co-operating with His Highness in the expulsion of the Common Enemy from Egypt, until the 16th July, 1801, when He made His Publick Entry into Cairo, as extracted by Lieutenant Colonel Holloway from his own Journal.

The Difficulties necessarily attendant on the March of an Army in a Country like that thro' which the Ottoman Troops have lately passed, have been considerably increased by a variety of unforseen Circumstances which have occured peculiarly unfavorable to their Progress; and could only have been overcome by that Energy and Perseverance, which have been manifested on the Occasion.

Towards the end of last Year the Army of His Highness The Grand Vizier, which had remained encamped at Jaffa from the time of its Retreat to that Place from Egypt, was in a Condition very unfit for a second Expedition. The Plague, which had prevailed during the Summer and Autumn, and was still raging with great violence, had very materially reduced its numbers; a dreadful Mortality afflicted the Cattle belonging to it; the Magazines of Stores, Provisions, and particularly of Forage, were by no means abundant; and the great

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Scarcity of Money had created Discontents among the Troops, which at times threatened the most alarming Consequences. Add to which that the tempestuous Weather at that Season of the Year, and the unsheltered Anchorage at Jaffa, rendered all Supplies by Sea (from which quarter they were chiefly to be expected) extremely precarious.

Such was the State of the Ottoman Army, (when on the 3rd December) advices were brought to the Grand Vizier by Lt. Colonel Murray Assistant Quarter Master General, of the Approach of a considerable British Force for the purpose of assisting the Turks in the Expulsion of the common Enemy from Egypt; and such continued to be the State of that Army, when M. General Moore (on the 9th Janry., 1801) came to the Imperial Camp from Marmorin, where the British Force had arrived, in order to concert with His Highness a Plan for the Co-operation of the Ottoman Army; and it was arranged that this Army should leave Jaffa on the receipt of an Intimation to that effect from the British Commander-in-Chief.

After the departure of M. General Moore (on the 14th Janry.) Preparations for Marching were begun: The Commander of their Artillery was directed to follow the suggestions previously given by Major Hope of the Royal Artillery and every means of assistance which the adjacent Country could possibly afford, was obtained without delay. The want of Forage for the Cattle was however a serious evil, as the Country offered no Remedy; but a temporary abatement in the weather at length enabled some Vessels laden with that Article, to land part of their Cargoes as well as some fresh troops brought from Albania.

The Grand Vizier perceiving the uncertainty of future Supplies during the Stormy Season, now became anxious to avail himself of that which he had just obtained, to move his Army to El Arish, where it had been determined for some time before to form Magazines. He accordingly ordered such Vessels as might in future arrive with Stores, to be sent to that place, and, without having heard from the Commander-in-Chief, left Jaffa on the 25th Febury., and encamped that day 12 miles from thence near the Village of Zabna. The same day however the *Termagant* Sloop of War arrived, bringing intelligence that the British Fleet was preparing to leave Marmorin for the Coast of Egypt, and also the expected Intimation for the Ottoman Army to move forward.

In spite of the Resolutions with which The Grand Vizier had quitted Jaffa, he found himself unable to proceed further than Zabna. The heavy rains had rendered the Roads in many places impassable to Artillery. The Plague, which after having carried off more than seven thousand of his Troops at Jaffa, had ceased in that Neighbourhood, was now raging with redoubled violence among the Troops composing his advanced Army at El Arish; the discontents owing to

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the Scarcity of Money again appeared; and lastly his Supply of Barley became expended during this unavoidable detention, and occasioned great distress.

Fortunately at this period Money arrived from Constantinople, and a further Supply of Barley. His Highness caused the Roads to be repaired, and on the 12th March, was again enabled to proceed; tho' on that day's march He lost upwards of Two hundred Camels owing to the Severity of the Weather.

While at Zabna the Ottoman Army was joined by about five hundred Men well armed and provided, being part of 5,000 ordered by Djizzar Pacha, who had entered into an Accomodation with the Porte, and was to grant this Reinforcement, as a Mark of the Sincerity of his Intentions.

On the 15th March the Army arrived at Gaza. It was here thought prudent to remain until the Plague should subside at El Arish. It ceased in a few days, after having in less than a Month reduced the Force at that Place from upwards of four thousand to about 1,500. Among its principal Victims were Ismael Pacha who Commanded at El Arish and several Persons of distinction, particularly Hassan Bey Djidda-oui, from whose zeal and enterprising Spirit The Grand Vizier and the Ottoman Ministry had formed very high Expectations.

His Highness availed himself of this delay at Gaza to settle an Arrangement with Lt. Colonel Holloway who Commanded the British Military Mission, for the future March of his Army across the Desert. It was accordingly determined that the Army should March in three divisions; the first under Tahir Pacha, as an advanced Guard, to consist of about three thousand Cavalry with 5 light Guns: the second under the immediate Command of Mehemmed Pacha, lately appointed Seraskier of the Army, to consist of about eight thousand Cavalry and Infantry with 8 pieces of light Ordnance; and the third under the Grand Vizier himself, to be composed of the Ottoman Ministers and their Suites, with the remaining part of the Army and Artillery.

It was further arranged that a British Officer from the Military Mission should be selected to accompany each of the two first divisions with Instructions from Lt. Colonel Holloway, and to give such Assistance and Advice as from their proffesional Judgement they might be enabled to afford the Pacha's, who in their turn were directed to consult with these Officers respectively on all Military Occurences.

On the 22nd March the division under Tahir Pacha proceeded to El Arish accompanied by Captn. Leake of the Royal Artillery. On the 28th The Grand Vizier with the Remainder of the Army advanced for that Place, and on the March received the account of the landing of the British Troops at Aboukir, and of the three successive Victories

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gained by them over the Enemy; which inspired universal Joy and was announced to the Ottoman Army by a Salute of 21 Guns from the Artillery.

His Highness arrived at El Arish the 30th March; and in conformity to the Arrangements made at Gaza, again sent forward (on the 2nd April) the division under Tahir Pacha, accompanied by Captain Leake, and on the 5th, the division under Mehemmed Pacha, who was accompanied by Captain Lacy of the Royal Engineers.

By Captain Leake, Lieut. Colonel Holloway sent with the Authority of the Grand Vizier Summons for the Garrisons of Teneih and Salaheik, which were however evacuated by the Enemy on the Approach of Tahir Pacha; tho' not until they had destroyed some of the works, and the Barracks of the latter, which was a Fort of considerable strength.

While the Ships were unloading at El Arish, a violent Storm came on, by which they were driven out to Sea, and the greatest part of their Cargoes, particularly the Barley, which had been landed on the Beach, was washed away. The distress occasioned by this misfortune is scarcely to be described; for four days the Animals which were very numerous in the Camp, were without Forage or Food of any kind, being situated two days march (nearly 40 Miles) in a barren Desert, which afforded not the smallest means of Sustenance for them. On the 5th and 6th days Biscuit and Rice were issued for them, after which some of the Vessels returned, tho' too late to save great numbers, which had perished with hunger.

To this Calamity succeeded another equally unexpected and disastrous. The Arabs, in consequence of some discontents suddenly deserted with their Camels, and deprived the Grand Vizier of the means of moving forward; nor could all the Exertions of His Highness aided by the Influence of the Sheikh of El Arish, procure Camels sufficient for more than a very small part of the division which remained with him. With these however He proceeded, accompanied by His Excellency The Reis Effendi, a few of their Attendants and some of the Troops. Those of the Military Mission who were of this Party were Lt. Colonel Holloway who Commanded the Mission, Major Hope, Commanding the Royal Artillery, Doctor Wittman, Mr. Wightman, Secretary, and Mr. Pink, Draftsman.

From the scarcity of Beasts of Burthen, such Articles only, as were indispensably necessary were taken by Land; and consisted chiefly of Barley and Water for the Cattle, Rusk and Water for the Men, being the sole food allowed to every description of Persons from the highest to the lowest, and a very reduced Proportion of Tent Equipage together with some Ammunition for the Field Pieces which His Highness took with him; the Remainder of the Baggage, Stores, etc., had been previously embarked on board Vessels at El Arish to

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be conveyed by water to Tenieh. The Officers of the Porte, with the Troops, Attendants, etc., and also those of the Military Mission, who were left behind in consequence of the Circumstances above stated, had directions to follow His Highness as soon as a sufficient number of Beasts of Burthen could be procured for them.

The Grand Vizier with the small Party which accompanied him, arrived at Catieh after four days' march, a distance of about 70 Miles. This may certainly be considered the worst part of the Desert, from the impossibility of procuring Water, after leaving the Wells of Messudie, 2½ hours (8 miles) beyond El Arish, until arriving at Catieh, where it is but very indifferent, tho' it may answer in Cases of necessity. The Road is for the most part hard and level tho' in some places the Sand is very deep and uneven and extremely difficult not only for Artillery but even for Horses, etc. It was marked by the Carcasses of Beasts and here and there of Men, who had dropt from Excess of heat and Fatigue added to the Misery of extreme Thirst: many were also observed laying on the burning Sand, and to all appearances expiring from the same Causes.

Under these truly distressing circumstances The Vizier afforded an Example of Firmness and humanity worthy of his exalted Station, being almost always seen on horseback sharing the general Fatigues and Hardships, and relieving as much as possible from his own few Comforts the miserable Objects that presented themselves.

While at Catieh (on the 23rd April) Lt.-Colonel Holloway sent by the Authority of the Grand Vizier, a Summons for the Fort of Lesbe at Damietta which was conveyed by Mr. Pink accompanied by a Turkish Secretary from the Reis Effendi who brought back an Answer from the Commandant, refusing the Terms offered.

Having halted at Catieh two days to give the Troops rest, and to allow time for the Stragglers to come up, His Highness continued his March, and on 27th April, arrived at Salahieh, being 18 hours (about 54 Miles) from Catieh. The Road between Catieh and Salahieh is in general more difficult than that to the former Place, tho' perhaps less to be dreaded, as water is to be procured on the second days March. It is intersected by a small Branch of the Nile, over which had been built a large Stone Bridge; this the Enemy destroyed on hearing of the Approach of the Ottoman Army in order to impede its Progress. The Grand Vizier on being informed of this halted the Night of the 25th April within a short distance of the Place; and sent on a party of Dehlis to make it passable, which they effected in a few hours. By this means the Party was not stopped a moment on its March, and arrived at Salahieh in less time by one day than the advanced divisions under Tahir and Mehemmed Pacha, who had taken a circuitous Route to avoid this obsticle. These Divisions had quitted Salahieh before the arrival of His Highness, and proceeded to Belbeis.

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On the 30th April, having been duly authorised by the Grand Vizier, Lt. Colonel Holloway sent Major Hope of the Royal Artillery accompanied by Amitchi Effendi the Secretary to the Sublime Porte, with a proposal to the Garrison of Cairo for entering into a Treaty for the surrender of that Place to the combined British and Ottoman arms which was rejected by General Belliard the French Commandant.

On the 5th May that part of the Ottoman Army and of the Military Mission which had been left behind at El Arish arrived at Salahieh.

On the 6th May, in consequence of the Refusal of the Garrison of the Fort of Lesbe at Damietta to surrender, by the advice of Lt. Col. Holloway The Grand Vizier detached against that Place Ibrahim Pacha of Aleppo, with three thousand Men, who when on the point of attacking that Fort, discovered that it had been abandoned by the Enemy during the night, which gave him possession of it on the Morning of the 14th.

On the 7th May The Grand Vizier advanced to Corin 6 hours (18 Miles) from Salahieh and having understood that some discontents prevailed among the Troops under Mehemmed Pacha tending to Insubordination, He proceeded the following morning to Belbeis where they were encamped, accompanied by His Excellency The Reis Effendi, Lt. Col. Holloway, Major Hope, and Mr. Wightman, Secretary, with a few Attendants, his Presence immediately restored Order and Tranquillity among the Men.

The Camp at Belbeis had been intrenched, and a Redoubt built under the direction of Captain Lacy of the Royal Engineers, and further precautions were likewise taken against suprise, by pushing Patrols to the Neighbourhood of Cairo to observe the Enemy's Motions.

On the 11th May that part of the Ottoman Army and of the Military Mission left at Corin, joined the Grand Vizier at Belbeis.

On the 12th May Intelligence arrived at the Camp of the Capture of Rahmanic, and the Retreat of the Enemy to Cairo, and on the Morning of the 15th Information was brought that He was approaching to attack the Vizier, which being afterwards confirmed His Highness who had frequently during the Day consulted Lt. Col. Holloway, towards the Evening ordered Tahir Pacha with three thousand Cavalry and three Pieces of Artillery to repair to meet the Enemy, and if a favorable opportunity should occur during the Obscurity of the Night to attack him. Tahir Pacha met the Enemy about three Leagues from Belbeis, who, on perceiving him halted as did also the Pacha. In this state both Parties remained during the Night and until 8 o'clock the next morning, when Tahir Pacha, having been reinforced with 1,500 more Cavalry, attacked the Enemy. Mehemmed Pacha soon after came up to his assistance,

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with about 5,000 Men and 5 Pieces of Cannon, and lastly the Grand Vizier himself, whose presence had the happiest Effects. The Enemy harrassed on all sides by the Turks, quitted Position after Position, at length seemed determined on a Retreat: the Turks followed them closely and in about seven hours from the Commencement of the Battle had driven him as many Miles from the Spot where it took place. His Highness then thought it prudent to Halt his Troops: and the enemy returned close to Cairo that Night. The loss on either side was inconsiderable, the Number of the Enemy in the Field, has since been known to amount to more than 5,000 including 600 Cavalry, with 26 Pieces of Artillery.

On the 18th May the Grand Vizier with the whole of his Army left Belbeis and halted that Night at the Village of Mashtoul, a little to the Westward of El Hanka. On the following day His Highness moved to Benalhasser, situated on the Eastern Bank of the Damietta Branch of the Nile, about 8 hours from Cairo, for the Convenience of communicating with General Hutchinson, The Commander-in-Chief of the British Army, and His Excellency The Captain Pacha, then encamped at Alkam on the Western Bank of the Rosetta Branch.

On the 20th May The Grand Vizier was joined by a detachment of British Troops sent him as a Corps of Reserve, under the Command of Colonel Stewart, consisting of the 30th and 89th Regiments, with some Cavalry and Artillery.

On the 24th May The Captain Pacha and General Hutchinson arrived at the Imperial Ottoman Camp at Benalhasser to concert with His Highness The Grand Vizier the future operations of the Campaign, when it was ultimately decided that the Combined Forces should immediately advance to attack Cairo. The Captain Pacha and General Hutchinson left the Camp on the 28th May to carry into Effect the Resolutions that had been agreed upon, and at the request of the latter His Highness ordered a Reinforcement of 500 of his Cavalry to join the British Army.

On the 1st June The Grand Vizier marched from Benalhasser, keeping the Eastern Branch of the Nile; the Forces under General Hutchinson and the Captain Pacha advanced along the Western Branch. From this period the Combined Armies proceeded, by slow Marches, halting for some days on the way, to give time for completing the necessary Arrangements, such as getting up the heavy Artillery and besieging Stores; and laying a Bridge of Boats across the Nile for an easy Communication between the two Armies. At length on the 20th of June General Hutchinson and the Captain Pacha encamped before Gizé, and The Vizier on the opposite side of the River before Cairo, the advanced Divisions being within Gunshot of several of the Forts. By these Movements the Enemy's Works became invested.

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At this time it is supposed the Army of His Highness The Grand Vizier consisted of about 20,000 Men, 12,000 of which were Cavalry, 1,000 Artillery and 7,000 Infantry, with 40 Pieces of Ordnance.

On the 23rd June the Enemy demanded a suspension of Arms which was granted by the Combined Armies for 48 Hours, during which time a Convention was resolved on between the respective Commanders, by which the Enemy was to surrender the City of Cairo and its Dependencies to the Combined Forces, and to evacuate Egypt. The Treaty was ratified on the 28th, and Hostages given on both sides. The Fort Shal Mouski on the East Bank of the Nile was given up and one of the Gates of Gizé on the West Bank to the Combined Forces; and the Enemy were enabled to finally evacuate Cairo on the 15th July and proceeded towards the Coast accompanied by most of the British Troops from Cairo, and by those of the Captain Pacha reinforced by a Detachment from the Vizier's Army. The Day following His Highness The Grand Vizier made his public Entry into the City under a General Discharge of Artillery, and amidst the acclamations of the Inhabitants.

On a View of the foregoing Statement, the Effects produced by the endeavours of His Highness The Grand Vizier and the Ottoman Army under His Command during the Campaign will appear as follows.

That this Army has performed a March of 240 Miles, 160 of them across a Desert and that under a Combination of the most unfavorable Circumstances; that it has driven the Enemy from Tenieh, Salahieh and Damietta, and taken possession of those Posts; that it has met in the Field a considerable number of French Troops having a numerous train of Artillery and aided by all the advantages which military Science and Discipline could give them, that it has engaged them for several Hours, has compelled them to abandon their Object and to make a retreat, at a Moment too, when the contrary Event would have had the most disastrous Consequences for the Common Cause; that it has been enabled from these Successes to effect a Junction with the British Army, and by various means to contribute by an effectual Co-operation towards the regaining of Cairo; and to the removal of the greatest part of the Enemy's Force from the Province of Egypt.

Lt. Colonel Holloway would feel himself wanting in an Act of Justice, were he to pass over unnoticed the Exertions of His Excellency Mahmoud Raif The Reis Effendi during the Events of the Campaign. His knowledge of European Customs and of a Language generally understood, added to his indefatigable attention to Public Business has created a facility of Communication which has been of the greatest Utility.

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Report by Major Hope, R.A., on the Defences of the Dardanelles.

BUYUKDERÉ,

1st September, 1799.

To BRIGADIER GENERAL KOEHLER,

Commanding His Brittanic Majesty's Forces, etc., etc., etc.

SIR,

In compliance with your Orders, I have in conjunction with Major Holloway, Commanding Royal Engineers; visited and examined the Defences, Batteries, Magazines, etc., at the Dardanelles.

When we consider the important and great National object they have to perform, nothing less than the preventing an Enemy's Fleet, from forcing a Passage to the Capital of the Ottoman Empire; which would never be attempted, or undertaken, but by a Force of great magnitude, we do not think the present Works, were calculated upon so extensive a Plan, as the momentous object entitles them to, and much fear, would not, under the present improved State of the Art of War, be found adequate to the great purpose for which they were built.

The Castles at the Entrance of the Dardanelles, (Cumcalli, on the Asia Side; and Setilbahar on the Europe) are as well situated as the width of the Channel will admit of, being 4,087 yards across, a distance rather too great for Artillery to act with precision, nevertheless, an Enemy should be met as early as possible, and impeded Step by Step, we therefore think it was judicious to take up these two points.

The next point taken up, is for a Battery of Nineteen Guns, called Eskisar, on a high Cliff on the Europe side, to the Eastward of the Castle, and although a long and plunging range, will bring on with the Castle of Setilbahar, an intersecting fire upon the entrance of the Straits; it should therefore be maintained and Armed with Ten or Twelve good Guns, 24 Pounders. The Channel from this widens so much, that no further opposition can be made, until the point de Barbier presents itself, where a Battery for Six heavy Guns should be made; as well as one of the same number, and nature on the opposite Shore; these two Batteries would establish a good and certain intersecting Fire; and being prepared for firing red hot Shot, which all Sea Batteries should be; would impede the progress of an Enemy's Fleet, and make them very cautious how they approached the Upper Castles Sultania and Keletbahar. These Castles are situated upon the narrowest part of the Dardanelles, but the position of the Castle of Keletbahar, is not so well chosen as it might have been, had it been placed on the point to the Westward of it; where it would have had a much better command of the Channel.

It behoves the Turkish Government seriously to exert every effort, and means in their power to improve and strengthen these Castles, by

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all the power of Art and Science. For, if an Enemy once passes the Grand Barrier there would remain no obstacle whatever of sufficient importance to check or prevent his accomplishing the object of his Design and making his way to Constantinople.

In obedience to your directions, I shall state the various defects at present existing in the four Castles and Batteries, and recommend such alterations, and improvements in the Artillery Department, as would be most advisable in my opinion to be adopted for the better security and defence of the Dardanelles.

The Guns, a few excepted, appear to me unserviceable, being flawed, full of cavities, some cracked, and pieces blown out of others. The Metal does not appear to be of a good quality, well purified, nor properly proportioned, being very brittle, and liable to constant accidents upon firing, an instance of which we were witnesses to; on the Island of Tenedos, the Guns, are most of them at present placed in front of the Great Guns, or Pierriers, where in case of an attack, they would be perfectly useless. The Gun Carriages are in general too large, for the Guns mounted upon them, very heavy, and ill constructed for narrow Ramparts; without Beds, Quoins, Spunges, Ladles, etc. The Shot lay about in all directions, mixed and unpiled, are old, corroded, very rugged and rough. The Magazines I have seen, require an admission of Air, and Copper Doors, otherwise are good. Powder, and every description of Ordnance Stores extremely deficient.

The chief opposition, and upon which great dependence seems to be placed at present to an Enemy's passing the Castles, are the enormous large Guns or Pierriers, some of which are nearly thirty Inches in Diameter; they lay upon Skids, under Archways, made in the Curtains and Bastions; cannot consequently be traversed, and only fired upon a moving object, when it happens to come opposite to their direction, it must however be allowed that if One of these large Stone Shot, which they project, was to strike a Vessel it would probably be her destruction; but as many of them break into pieces after leaving the Guns, they are of course, very uncertain in their effect, and not to be alone depended upon; but as it may be advisable to make use of them it is proposed to let as many remain under the Archways, in the Curtains next the Channel, with the alterations proposed by Major Holloway as there may be places for them; but must observe that the principles approved and adopted of late years, for Sea Batteries, has been to endeavour by every possible means to move the Guns with facility by Traversing Carriages, or Platforms, so as to be enabled to follow the direction of a Vessel as she sails, and to fire upon the same object as often as possible.

A Mixture of a variety of different Natures of Ordnance, being even among the best established Artillery liable to create confusion, and occasion mistakes, particularly at a time when every precaution should be taken to guard against it, that of an attack, to avoid which, I beg

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leave to recommend to the Turkish Government, to Arm the Old and New proposed Works in the four Castles, with only three kinds of Ordnance, Viz., 24, 18, and 12 Pounders, or Guns nearly answering to those Calibers, in the Number and Manner stated in the returns numbered 1, 2, 3, and 4; to which I have added a list of the requisite quantity of Ordnance Stores for each nature of Ordnance, calculating upon 150 Round Shot and 20 Case or Grape per Gun for the 24 and 18 Pounders, and 50 Round Shot, and 20 of Case or Grape for the 12 Pounders Gun. The Guns should be mounted upon Carriages constructed on the principle of our Garrison Carriage; they will be better adapted to their narrow Ramparts, require fewer Men to serve them, and be easier worked.

Such Howitzers as are in my return proposed for the Castles, should be mounted upon proper Carriages, made expressly for them. The Ammunition proposed for them, is at the rate of 200 Shells per Howitzer, and the same number of Shells, etc., are proposed for the Sea Service Mortar, two of which should be in each Castle.

As it is not to be supposed that these Castles will at any time be attacked both by Sea and Land together, I have regulated the proposed number of Artillery Men, by the number and nature of the heavy Ordnance, which if kept up in time of War, will I should suppose be fully adequate to the service of the Guns on the Castles at all times.

The Number of Non Commissioned Officers, and Gunners, required for the different Castles, and Batteries will be as follows. Viz.:

	Non Comd. Officers.	Gunners.	Total.
Camcalli	20 ...	203 ...	223
Setilbahar	27 ...	270 ...	297
Sultania	30 ...	334 ...	364
Kiletbahar	15 ...	156 ...	171
Equisar Battery ...	6 ...	60 ...	66
Point de Barbier, and opposite Battery ...	6 ...	60 ...	66
	104	1083	1187

The Number of Artillery Men, and quantity of Ammunition, etc., for the Pierriers are not included in this Statement as, their exact number is not yet fixed upon.

The next object of great importance, and strongly to be recommended for the Defence and Security of the Dardanelles, is the Establishment of a Regular Corps of Artillery for the service of the above mentioned Ordnance, properly Officered, with a sufficient number of Non-Commissioned Officers. This Corps should be well trained in the Exercises of the Guns, Howitzers, and Mortars; as well as instructed in every Branch of Artillery, necessary to make

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them good and expert Gunners. They should be paid and cloathed by the Government, and that regularly. Barracks or Quarters should be provided for them, and their daily rate of subsistence should be sufficient to maintain them. The pay of the Non Commissioned Officers should be more than that of the Private or Gunner.

The Ordnance Stores should be put under the charge of a Storekeeper, who is to be answerable and accountable to the Government for the Stores, he should have a Clerk and be allowed a sufficient number of Labourers to enable him to keep the Stores in good regular Order. He should keep an exact account of all the Stores he receives and Issues on account of the Service, and send a Monthly state of them to the Government. A Second Person as a Check upon the Storekeeper should also be appointed, as Clerk of the Cheque, who is to have at all times free access to the Magazines and Stores; is also to keep an account of all Stores received and issued jointly with the Storekeeper, and to report to the Government any misapplication of them that may come to his knowledge. Thirty rounds of Ammunition per Gun should be kept constantly ready and lodged in Expense Magazines near the several Batteries, Kilns, or Furnaces for heating of Shot should be erected.

As Iron Ordnance is infinitely preferable to Brass, and generally used in our Garrisons, being more durable and not liable to be injured by firing in the manner that Brass is; particularly if the Metal is not sufficiently hard and tenacious. I therefore recommend Iron Guns for the Castles and Batteries; Should the Sublime Porte judge it proper to adopt any part of the proposed alterations and improvements.

About a Mile and a half to the Westward of the Castle of Setilbahar, is a Battery for Nine Guns, in which there are at present 5 Light Field Pieces; these should be removed, and the Battery armed with heavy Guns, if it is intended that this Battery should remain; one placed on a point between it and the Castle, would answer the double purpose of forcing an Enemy's Fleet to keep a respectable Offing, and be a greater protection to the Castle.

When Major Holloway has compleated his plans and projects, for the intended Works in the rear of the Castles of Setilbahar, and Kiletbahar; I shall have the honour of laying before you some further Remarks, and Observations, as well as the necessary Returns of the Ordnance and Stores for them and the Batteries.

I have the honor to be,
Sir,
Your most obedient
humble Servant,
R. HOPE,
Commdg. British Royal Artillery
and Major.

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BONYOUKDERE,
21st September, 1799.

To BRIGADIER GENERAL KOEHLER, etc., etc., etc.

SIR,

The undermentioned Articles will be required for examining, and removing the different Natures of Ordnance in the Castles at the Dardanelles, etc., Viz. :—

Gins compleat	4
Sling Carts	2
Truck Carts	2
Sledge Carts	2
Searchers	4
Relievers	4
Prickers	4
Iron Crows	6
Crab Capstans...	2
Spars	6
Skids large	12
Do. small	12
Shot Gauges sets	4
Men's Harness sets	24
Coils of different sized Rope...	3
Blocks and Tackles.	
3 In. Planks	12
Handspikes, large	12
„ small	24

Such Pickaxes, Shovels, etc., as may be wanted can be borrowed from the Engineer's Department.

I have the Honor to be,
Sir,
Your most obedient
Humble Servant,
R. HOPE,
Comdg. Royal Artillery
and Major.

To BRIGADIER GENERAL KOEHLER,
Commanding H.B.M. Forces, etc., etc., etc.

Return of the Number and Nature of Ordnance for the proposed Tower and Battery on the small Island off Tenedos.

24 Pounders mounted on Garrison Carriages Compleat	15
Stores for Ditto.	
Handspikes	60
Spunges	15
Ladles	8

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Wadhooks	8
Linstocks	8
Tampeons	15
Aprons of Lead	15
Powder Horns and wires	8
Punches for Vents	8
Spikes	15
Claw Hammers	6
Shot { Round	1,500
Shot { Case or Grape	300
Cartridges empty	1,900
Wads	3,800
5½ In. Shells fixed	100
Tongs and Bearers	4
Water Buckets	3
Portfires, dozens	2
Portfire sticks	4
Powder Barrels, 90 lb.	170
Bridge Barrels	1
Powder Measures from 1 lb. to 4, sets ...	1
Slow Match, cwt.	2
Tubes	500
Tube Boxes	4
Tanned Hides	2
Hair Cloths	2
Wadmill Tilts...	2
Lanthorns { Muscovy	2
Lanthorns { Dark	2
Sheepskins	6
Spunge Tacks...	600
Tarred Marline, skeins	6
Gins Compleat	2
Portfire Clippers	4

R. HOPE,
Comdg. Royl. B. Artv.
and Major.

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Colonel Geo. Strahan, R.E.

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MEMOIR.

COLONEL GEORGE STRAHAN, R.E.

By Col. S. G. Burrard, f.r.s., R.E., Offg. Surveyor-General of India.

George Strahan, the son of William Strahan, was born at Ashurst in Surrey in 1839. He was educated at Eton, and in 1857 he entered the Military College of the Honourable East India Company at Addiscombe. He obtained his commission in the Bengal Engineers in 1858.

His eldest brother, William, was in the Artillery and died many years ago. His three younger brothers survive him; Aubrey entered the Geological Survey of Great Britain and is now a distinguished geologist. Henry is the Mayor of Hythe, and Charles, following his elder brother's example, obtained a commission in the Bengal Engineers, and after being Surveyor-General of India has now retired from the Government service.

The subject of this memoir won the sword of honour and the prizes for mathematics and drawing at Addiscombe, and his name is on the old boating cup in the Chatham Mess. This cup was competed for in an annual four-oared race by crews of the Royal and Indian Engineers. When the Indian Engineers were amalgamated with the Royal, the competition ceased. The last race was rowed in 1861, and on the cup at Chatham he is named as having rowed number three in the Indian boat in 1859 and as having been stroke in 1860.

Strahan went to India in 1860 and joined at Calcutta. He was first posted to the Bengal Sappers and Miners at Roorkee, and subsequently to the Irrigation Branch of the Public Works Department at Hardwar, the head works of the Ganges Canal. He remained in Irrigation for 15 months and in July, 1862, was appointed to the Topographical Survey of India. He entered this branch at an important turning point in its history. From 1800 to 1825 the Topographical Survey of India had been based on military route sketches. From 1825 to 1850 topographical maps had been mainly derived by reductions from large scale revenue surveys. No Indian maps of an earlier date than 1850 give any idea of vertical relief. It was between 1850 and 1860 that topography in India made its first stride in advance. Talking of

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this advance Strahan used to say in his enthusiastic way: "It was all due to Dan Robinson."* He would acknowledge that the introduction of the plane table had proved of great advantage to topographers, and that the publication of Waugh's *Instructions* and Thuillier's *Manual* in 1853 had had considerable effects, but he always insisted that Robinson was the originator of the modern system of delineating ground. If we now look back upon the old maps of India we are struck at once with Lieut. Daniel Robinson's (1 inch=1 mile) maps of the intricate country between the Indus and the Jhelum, which were made between 1851 and 1859, and which are immensely superior to all others of that date. It is no exaggeration to say that these maps constitute an epoch in the history of topographical surveying. Robinson's maps of the Indus-Jhelum country (1851—1859), and Montgomerie's maps of Kashmir (1855—1865) were the only good topographical maps of India that were in existence when Strahan joined the Survey. Even these maps fall below the modern standard in that they furnish so few values of height.

In 1862 there were four topographical parties, and on his appointment to the Survey Strahan was posted to No. 1 Party (Gwalior and Central India). In 1857-58 the absence of all maps of Central India had proved very embarrassing during the advance of Sir Hugh Rose's columns, and in 1860 Capt. Daniel Robinson, who had just completed his surveys in the Northern Punjab, was directed to initiate the topographical survey of Gwalior, Central India and Rajputana on the 1 inch=1 mile scale. This was a vast undertaking, the area embraced exceeding 200,000 square miles.

In 1860-61 Capt. Robinson commenced the triangulation and extended it over 3,300 square miles, and in 1861-62 he started the topographical work. The records of 1861-62 give the names of the military officers with the Central India Topographical Party thus:—Capt. D. G. Robinson, R.E., Superintendent; Lieut. G. Strahan, R.E., Assistant Surveyor.

The expenditure on the party in 1861-62 was 55,000 rupees. In 1862-63 there were three military officers with this party and they are shown in the records thus:—Lieut.-Colonel D. G. Robinson, R.E., Superintendent; Lieut. G. Strahan, R.E., and Lieut. R. V. Riddell, R.E., Assistant Surveyors.

In 1862 Robinson reported to the Surveyor-General as follows:—

"My instructions to Lieut. Strahan were to carry the triangulation down to latitude 25°, remeasuring the great triangles if weather would permit; if not to confine himself to covering the ground with secondary triangles based on the old stations of the Great Arc. The weather became too hazy to admit of Lieut. Strahan doing more than

* General Daniel Robinson, C.B., R.E., joined the Survey of India in 1845. He was Director-General of Telegraphs from 1865 to 1877.

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fulfilling the second part of my instructions, and that he did with so much difficulty and he suffered so much from exposure that his health has been in a very bad state ever since."

In 1863 the Surveyor-General (Sir Henry Thuillier) reported as follows to Government :—" Lieut. Strahan's practical knowledge is of great value. I am happy to be able to state that he has improved in health and is likely to remain at his post. He is an officer of the highest promise and merit. Lieut. C. Strahan, R.E., joined early in November in time to accompany the Central India Party into the field, where he is now undergoing instruction and taking an active part in the operations under his brother's excellent guidance."

In 1862-63 the topographical out-turn of the party was 3,457 square miles; George Strahan himself completed all the triangulation, besides 200 square miles of plane tabling.

The Surveyor-General now represented to Government that the topographical survey of the immense area allotted to No. 1 Party would not be completed for 60 or 70 years, and in 1863 a new party, No. 7 (Rajputana), was created. Both No. 1 (Central India) and No. 7 (Rajputana) were at first placed under one Superintendent. On Colonel D. Robinson being appointed to act for General Walker as Superintendent of the Trigonometrical Survey, Capt. A. B. Melville of the Kashmir Survey was appointed to take his place in Central India and the military officers of the two parties were distributed as follows :—

Capt. A. B. Melville in charge of Nos. 1 and 7 Parties.

No. 1 Party (Gwalior and Central India)—Lieut. G. Strahan, Assistant Surveyor.

No. 7 Party (Rajputana)—Lieut. C. Strahan, Assistant Surveyor.

In 1864-65 No. 7 Party (Rajputana) was formally separated from No. 1 (Central India), and was placed under the superintendence of Lieut. G. Strahan. In reporting to Government of his intention to separate the two parties, the Surveyor-General wrote :—

" Lieut. G. Strahan is an officer of great ability and excellent business habits. He has received his training in a good school. When inspecting the work executed by him last field season, I was fully satisfied with all that has been done. This officer excels as a draftsman."

In 1864 Mr. W. Stotesbury, who was for many years to come one of George Strahan's principal assistants, joined the Survey and was posted to No. 7 Party.

In 1864-65 Strahan moved his party to its new area (Jaipur and Alwar), and, as no triangulation was ready, he confined the operations for this season to triangulation. 7,300 square miles were triangulated between November and April: of these Strahan himself did 5,286 square miles.

The advent of railways has so revolutionized procedure that it may

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be of interest now to recall how survey parties used formerly to take the field. During the summer of 1865 Strahan had his office at Mussoorie. Early in October he recalled his native surveyors and khalasis from leave and assembled his party at Dehra Dun. He then started with a few elephants and a hundred camels on his long journey to Rajputana. For two months the early mornings were spent in marching; camp office used to be opened daily and during office hours the triangulation of the previous season was computed, points were plotted on plane tables and all preparations for field work were made. The march continued till November when the party reached its destination. Field work was carried on till April, when the scattered members of the party met again for their long march back to the hills which they reached towards the end of May.*

In after years I once heard one of Strahan's assistants (Mr. W. W. Macnair) say that "on the Rajputana Survey Colonel Strahan used to do everything at a gallop. On horseback the only pace he recognized was the gallop. His camels were unloaded and his camp was pitched at full speed; theodolites were erected, and observation taken without pause. He was so constituted, that he never wanted leisure nor rest except during sleep."

There is little doubt that the strenuous life in Rajputana and the constant necessity he felt of working against time and of pressing and urging others, formed in him habits that made it difficult for him in later life to take kindly to the patient and accurate methods of geodesy.

I do not think that George Strahan served under General Robinson after 1863, but to the end of Strahan's life Robinson was engraved upon his memory as a hero. I remember a few years ago Strahan being delighted one day at coming across Robinson's old shikaree. "Just fancy," he said, "my meeting that old chap again. I used to see him often in Dan Robinson's howdah 40 years ago."

The Survey of Jaipur and Alwar was continued throughout the winter season of 1865-66 and 1866-67. The following extract is from Strahan's report for 1866-67 :—

"The camp left Dehra on October the 1st and the whole party were assembled at Delhi on October the 15th. Five days' march brought it to the frontier of Alwar where the ground allotted to Mr. Tod lay. On the 11th day Messrs. Baness and Stotesbury were detached to their ground and on the 16th day Messrs. Tapsell and Hussey were detached. I reached Jaipur on the 19th day's march from Delhi. I then commenced the triangulation of the city preparatory to the survey on a scale of $500' = 1''$. The traversing and computation were sufficiently advanced in a fortnight for me to commence a detailed survey. The Survey of Jaipur comprises eight plane-table sections; two of these I completed myself, as a sort of pattern

* Colonel Bythell's article on Surveys—*Imperial Gazetteer*.

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of what I wished done. I then left Mr. Kitchen to complete the rest. Much delay was occasioned by the necessity of sending word to the authorities every evening of the exact spots which we wished to visit next day. The first day on which I approached one of the forts in Jaipur, without having any authorized official with me, they threatened to fire unless I immediately withdrew. I had several interviews with the Maharaja, as I considered an explanation of the uses of an accurate plan of his city and territory in person, would do more to secure his co-operation than any amount of writing. He took great interest in the theodolites and other instruments which I showed him."

During the winter season of 1866-67 the Surveyor-General received an urgent request from Government to make immediate arrangements for the survey of the site of the new cantonments for European troops, which were to be erected at Pokri in the Himalayas. Sir Henry Thuillier thereupon directed Lieut. Strahan to close his regular operations and to proceed to Pokri with all his assistants as quickly as possible. At Pokri the operations consisted of making a survey of the crest of a range, 5 miles in length, scale 1″=200′, contoured at 10′ intervals. Sir H. Thuillier subsequently reported to Government as follows :—" Lieut. Strahan is entitled to much credit for the manner in which he carried out this survey. He had no assistant with him who understood levelling. The map of Pokri is interesting as being the result of the first contoured survey which has ever been made in the Himalaya Mountains."

The following extract is from Strahan's own report (dated 1867) on the Survey of Chakrata :—

" We were compelled to leave the field in Rajputana one month earlier than usual having been called upon to execute the survey of the site of the new cantonment at Pokri. The party were all assembled at Delhi on April 1st and proceeded without delay to Pokri. This change has most unfortunately delayed the out-turn of my maps. This is the more to be regretted as on reaching Pokri I found that we were there before we were required. From your letter I concluded that the site for the cantonments was fixed and nothing remained but to make a contoured survey of it. General Wheeler must have been strangely misinformed on this matter, for I found that the Committee wished me to contour the range for 8 miles to *enable them to select a site*, a task impossible to complete under four or five months. Under these circumstances I recommended a reconnaissance first, and then when the site was determined a contoured survey of it. This did not however meet with approval, and I commenced the contouring of Chilmeri Hill at Capt. Peile's request. I had completed two-thirds of this when the President of the Committee wished me to survey a ridge beyond, called Chakrata. This I completed, and was then requested to go back to Pokri and complete Chilmeri Hill, the latter being the site still in favour with Capt. Peile. This vacillation induced me to refer the matter to you.

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"As this is the first contoured survey executed in the Himalayas I shall enter somewhat fully into the methods employed. I adopted two systems, one at Chilmeri and one at Chakrata. First, at Chilmeri I selected a central point and with a theodolite I marked out from it two lines at right angles. This I intended to be the basis of the survey. I then proceeded to level these lines having large pegs at every 20' vertical rise or fall. I then measured the horizontal distances between the pegs by means of wooden rods. Secondly, at Chakrata instead of having straight lines I followed the winding of the summit of the range, and I laid out cross-lines at intervals corresponding to conspicuous watersheds. This change necessitated the traversing and plotting of the central and cross lines. On the other hand keeping to the summit of the ridge diminished the labour of levelling, and is, I think, best adapted to this style of survey."

On November the 9th, 1867, Strahan left India on furlough on medical certificate. He had then been in charge of the Rajputana Survey Party for $3\frac{1}{2}$ years. In his report for 1867 the Surveyor-General wrote as follows :—

"All the maps of No. 7 Party (Rajputana Survey) are admirably executed and are decidedly the best of the season. I have much pleasure in testifying to the very creditable manner in which Lieut. G. Strahan has performed his duties. I much regret that the failing health of this talented officer has deprived the Department of his services for the time."

In July, 1869, Strahan returned from England and resumed charge of his former party, No. 7 (Rajputana). Sir Henry Thuillier wrote to Government :—

"I have personally discussed the new Rajputana programme with Lieut. Strahan whose return to the Department I gladly hail."

In 1869-70 Strahan took up the Survey of Jodhpur, Udaipur, Sirohi* and Ajmere, and he made a large scale survey (6 inches = 1 mile) of the great hill of Mount Abu.

In his report for 1870 Strahan pointed out that there was too large a gap in the principal triangulation of the desert and that his own secondary triangles could not be extended over such an enormous area without risk of undue accumulation of error. At Strahan's representations General Walker decided to run two more principal series of triangles across the desert.

Strahan himself observed great numbers of secondary series of triangles across the gaps between the principal series, and he always eliminated the errors of observation by the method of least squares,

* Long after Colonel Strahan had retired from the Service, the Sirohi Durbar wrote and asked him to return, and see whether their state boundary pillars had not been moved. He returned then to his old haunts in Rajputana after an absence of 35 years.

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polygon by polygon, and at the close of each series he would distribute the closing errors by the rigorous methods of geodesy. The scientific way in which he adjusted his errors has given his triangulation a high and permanent reputation.

In his report for 1870 the Surveyor-General wrote to Government as follows :—

"It gives me the greatest satisfaction to bear testimony to the zeal, ability and systematic regularity with which Capt. G. Strahan has conducted all the duties entrusted to him. I have repeatedly in my reports to Government drawn special attention to the excellent services of this able officer."

In 1870–71 the Rajputana Survey was extended over Udaipur, Kotah, Indore and the Aravalli Mountains. The topographical outturn for this year was 3,551 square miles. The triangulation done by Strahan himself was 2,493 square miles.

In 1871 the Surveyor-General reported :—

"Further important employment has been found for this party, which is peculiarly qualified to undertake surveys of difficult ground of an intricate character. The sanitarium of Simla has long needed a careful survey on a large scale. It is therefore proposed to withdraw the party from Rajputana by the end of March to Simla, where they will be able to prosecute the new survey in the hills. In this way I hope to obtain good plans of the several military stations of Jutogh, Kasauli, Dagshai, Sabathu, in addition to Simla."

Capt. Strahan was thus in the field in Rajputana from October to April ; and during May, June and September he was employed on the triangulation of Simla.

In 1871–72 the topographical programme of his party was as follows :—(*a*). Survey on 1" scale, Jodhpur in the winter. (*b*). Survey on 24" scale, Simla, in the summer.

The Surveyor-General's report on the maps of the year was :—

Rajputana.—"Delineation of the ground, good and effective."

Simla.—"The six Simla sheets completed, of which three have been fair drawn by Capt. G. Strahan and three by Mr. Stotesbury, are admirably finished specimens of hill-drawing on a large scale and faithfully represent the ground.

"The labour of drawing these sheets is very great and demands first-rate artistic ability."

In the Simla sheets an attempt was made to follow the English scale of shade. This scale of shade had been found of use in indicating the relative steepness of slopes when troops were manœuvring over the downs of South England but Strahan regarded it as unsuitable to the Himalayas.

In 1872–73 Strahan's party was employed from November to April in the Marwar State of Rajputana and from May to September on

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the Survey of Simla. The party was in the field and engaged upon outdoor work for 9 months out of the 12. The Surveyor-General in 1873 reported to Government :—

"I find it difficult adequately to express again the high sense I entertain of Capt. G. Strahan's attainments and management. The Survey Department owes this talented officer much for his successful prosecution of surveys of varied character of the highest order of merit."

In 1873-74 the Survey of Rajputana was continued in the winter and that of Simla was completed in the summer. In Rajputana the survey was extended from Ajmere to the borders of the Bikanir Desert. Of this desert Strahan reported :—

"Water is brackish and only found at great depths. I measured one well over 400' deep. According to the inhabitants the sandhills do not shift their positions to any great extent and I hope that some of the principal triangulation stations which I had to build at great expense will prove permanent. I was surprised to find that a system of telegraphy by looking-glasses flashed in the sun was in use across the desert to Bikanir. It is employed by the opium merchants to ascertain whether opium is selling at a cheap or high rate at Calcutta."

The year's out-turn of topographical survey in Rajputana was 3,170 square miles; Strahan himself completed 2,160 square miles of triangulation.

In 1874 the Surveyor-General reported to Government :—"The Simla Survey has been satisfactorily finished. In addition to the elaborate large scale sheet plans, 20 in number for the Simla Survey, Capt. G. Strahan has drawn a most artistic general plan of Simla and Jutogh in brush shading, 8 inches = 1 mile. It is a matter of congratulation that the double object of the survey in Rajputana and of the laborious large scale survey of Simla has thus been successfully and efficiently accomplished. An admirable out-turn has been effected in both cases at a most moderate cost."

The month of December, 1874, is memorable in astronomical annals for the transit of Venus. This was the first transit of Venus that had occurred since 1769, and as it was to be visible from India, the Government decided to have it observed from four places. The distance of the earth from the sun was less accurately known in 1874 than it is now, and the passage of Venus across the sun's disc was expected to yield important data. There were six observers in all and they were distributed as follows :—

General J. T. Walker at Dehra Dun, Mr. Hennessey at Mussoorie, Colonel Tennant, Capt. W. M. Campbell, Lieut. Waterhouse at Roorkee, Capt. G. Strahan at Lahore.

The following is an extract from Strahan's letter to Colonel Tennant, dated December the 17th, 1874 :—

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"The instrument I used for the transit was a 6" refractor. The transit instrument used for time is one belonging to the Great Trigonometrical Survey of 30" focal length. I commenced observing transits of stars on November the 21st and continued without the exception of a single night until December the 10th. There can be little doubt that the times recorded during the transit of Venus when reduced for error and rate are true within a few hundredths of a second. Having satisfied myself as to the best position of the chronometer and having made experiments on eye-pieces and apertures, I awaited the phenomenon without anxiety. The weather on the morning of the 9th was all that could be wished. Ingress was not visible so far up country as Lahore, and for about an hour after sunrise the sun's limb and the planet were trembling a good deal, but as the sun got higher the definition became better, till about 15 minutes before contact the edges of the two bodies were sharply defined. As the planet moved towards the sun's limb she appeared to push out the edge of the sun before her, the cause of which phenomenon became evident in a few seconds. The planet's edge was encircled by a ring of light nearly as bright as the sun's disc which prevented any contact from ever taking place at all. There was no appearance whatever of a black drop or ligament. An elaborate discussion of my observations would be out of place, but I am tempted to make a few remarks upon appearances so unexpected. There can be little question that they point to the existence of an atmosphere on the planet. The ring was visible up to the time of external contact and from this a rough estimate of the refractive power of the planet's atmosphere may be made. The deviation of a solar ray amounts to 1 minute, 27 seconds of arc. During the transit, I kept a careful look-out for a satellite of Venus and also for any peculiar appearances in the planet's shape but I never detected the slightest deviation from a clear hard circular edge."

In 1874–75 the Rajputana Party had to take up the Survey of Kishengarh and Shekawati. Strahan being away for the transit of Venus, the party was taken into the field from Simla by Lieut. E. P. Leach (now General Sir Edmund Leach, V.C., K.C.B.). Strahan rejoined the party in Rajputana in January and commenced a large scale survey of the towns of Ajmere and Kishengarh. The total topographical out-turn for the year was 3,741 square miles. The total annual cost of the party was Rs.64,000.

In 1875 Capt. Strahan was transferred from Rajputana to Mysore. The following extract from the Surveyor-General's report of 1876 explains the transfer :—"The services of an experienced officer having been required to start a new topographical survey of the Mysore State, Capt. G. Strahan, R.E., who had most successfully conducted the operations of the Rajputana Party for 11 years was recommended for this duty and with the sanction of Government was transferred to the charge of No. 8 Topographical Party, from October the 1st, 1875."

Lieut. Leach succeeded Capt. Strahan in charge of the Rajputana

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Party and the latter's connection with Rajputana terminated. The Survey of Rajputana was continued till 1885, by which time the whole area had been mapped, with the exception of the interior of the desert.

Strahan had spent 13 years on the Survey of Rajputana, and had been in charge of the Rajputana Party for 11 years. In after-life he used to refer to his time in Rajputana with enthusiasm. "It is," he used to say, "the healthiest country in the world. In 13 years I never lost a man." Speaking of the rocky conical hills that protrude at intervals of 10 miles out of the flat sandy wastes of Marwar he used to say "Marwar was created for triangulation. The absence of water makes it useless for any other purpose. It must have been created for triangulation only."

In 1900 the topographical maps of India were subjected to a rigorous examination by Colonel Gore, Surveyor-General, who was reporting to Government upon the topographical requirements of the country. Of Bengal he reported that, out of 433 sheets, "285 were useless"; of Northern India he reported that "the surveyors had had little idea of surveying hill features." Referring to the Central Provinces he said, that "the maps did not satisfy modern requirements." In Madras, he said, "no attention had been paid to accuracy of details." With regard to Hyderabad, he reported, that the surveys had been commenced in 1816 and that nothing was known as to how they were executed, that they were sketchy reconnaissances. His report on the Rajputana maps was :—

"The Rajputana maps are good, sound, topographical maps of an excellently even quality, and were all published within one year of the date of the field surveys."

In 1875 the Government of India directed that immediate steps should be taken to commence the topographical survey of the Native State of Mysore. Mysore is a rocky triangular table-land, containing large areas of mountain and forest and studded with vast numbers of tanks. The topographical party was formed under Capt. G. Strahan, and as a nucleus three of his most efficient assistants, Messrs. Kitchen, Stotesbury and Macnair were transferred with him from No. 7 (Rajputana) Party to the new No. 8 Party (Mysore). The annual cost of the Mysore Survey was estimated at 80,000 rupees ; the scale of survey was to be 1 inch = 1 mile.

As there was no triangulation ready for the topographers, the party for the first field season, 1875–76, was limited to the four officers only, and all these were employed on triangulation. The out-turn of triangulation was :—Capt. G. Strahan, 1,740 square miles ; Mr. F. Kitchen, 1,160 square miles ;. Mr. W. Stotesbury, 1,160 square miles ; Mr. W. W. Macnair, 1,520 square miles. Total, 5,582 square miles.

In his first report on the Mysore Survey, Strahan wrote :—

"So far the appearances of the ground lead me to suppose that both

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triangulation and plane tabling can be accomplished without difficulty. There are plenty of low rocky hills suitable for stations. There may be a little trouble here and there in fixing the plane table, where cocoanut plantations abound; considerable care will have to be exercised in the delineation of the undulations of the ground."

In the following year, 1876-77, it was fully expected that the area triangulated would have been surveyed in detail, and the Mysore Party was raised to its full strength; but a great famine and drought prevailed throughout Mysore and stopped the survey operations. The Surveyor-General reported to Government :—

"Capt. Strahan much fears that very little of the ground specially prepared for topographical delineation can be visited, and it will be difficult to carry on any connected operations whether of skeleton triangulation or of topography, in any part of the province. The accounts received up to date of the state of the province are exceedingly gloomy. The usual out-turn cannot now be expected, but Capt. Strahan is making every endeavour to utilize his establishment and to feed them by judicious commissariat arrangements."

At the close of the field work the Surveyor-General reported to Government :—

"Famine prevailed throughout the Southern Peninsula; Capt. Strahan's party had to be scattered and could not carry on their work in a compact block; they could not enter the greater part of the country that had been triangulated and prepared for detail survey. Capt. Strahan selected certain localities in which it was possible to obtain water, provisions and forage. The out-turn of work for the year was 1,465 square miles of topography, 5,280 square miles of triangulation."

At the close of field work in April, 1877, Capt. Strahan took furlough and the Survey of Mysore was placed under the charge of Major (now Sir H. R.) Thuillier. In the winter of 1877-78 Major Thuillier reported :—"The prospects of Mysore are much better than could have been expected; the famine and pestilence have disappeared, pasturage and cultivation are everywhere and suffering is nowhere visible. The survey work is progressing favourably."

In 1879 Major Thuillier went on furlough and Strahan resumed charge of the Survey of Mysore. During the winter of 1879-80 the survey was extended over the Western Ghats. The rugged nature of these mountains, the density of the jungles and the absence of roads and supplies were obstacles to progress. Strahan wrote :—"Ordinary methods of working with the plane table are in many places impracticable; resort has to be had to special methods, especially to that known as plane-table traversing, in which the plane table supplies the place of an angular instrument and the measurements are made by chain. This is always slow, and when

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chain lines have to be cleared through forests, progress is slow indeed."

In 1880 Mr. Chew, the senior assistant, died of malaria.

Between 1875—1881 there had been surveyed in Mysore 12,754 square miles, and according to the original estimate of area there remained for survey 14,250 square miles. But in 1881 Strahan reported that the anticipated area of 27,004 square miles was too small, and that the true area of Mysore exceeded 30,000 square miles.

In 1880-81 he carried the triangulation along the Bababun Hills, which he described as being covered by a dense mass of bamboo jungle, inhabited by elephant and bison. No greater contrast to the bare hills and plains of Rajputana can be imagined than that presented by the forests of Mysore.

In 1880 the question of a clinometer, which could be used by plane tablers, was first raised. Before that date all heights on maps were obtained from levelling or from the vertical angles of triangulation or from barometers. It had become evident to topographers that no improvement in the representation of vertical relief upon maps could be expected until the numbers of observed heights were largely increased.

In 1880 General J. T. Walker issued his clinometric shade scale. This was the first clinometer tried in India; it consisted of a cardboard quadrant with plumbline attached. Walker estimated that vertical angles could be measured by means of it within 15 minutes of arc, so that the error in height should not exceed 0·005 × (distance in feet).

At 2 miles distance the error would be 50′. "It is much better," Walker wrote, "in hilly country to have a height in error by 50′ than to have no height at all."

Strahan tested Walker's clinometer in Mysore throughout the field season 1880-81. He reported as follows:—

"The results are disappointing; high winds are prevalent in Mysore and I found by my own experience that a very gentle breeze was sufficient to render the results so wild as to be little better than what an experienced eye could obtain by guess."

Strahan then designed a new clinometer of his own, and this was tried by his assistants and found to give results better than those obtained by Walker's instrument. The following observations of a height are typical of many, which were obtained with one of Capt. Strahan's clinometers:—

Distance of Point in feet.	Resulting Height in feet.	Difference from Mean in feet.
41,270	2,560	+34
29,850	2,531	+ 5
30,200	2,488	−38

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The discrepancies were considered too large ; but if we may judge from subsequent experiences Strahan was expecting too much. The distances, at which the instrument was tested, were excessive. Even the modern clinometer could not be trusted to give correct heights at a distance of 41,000′ (7½ miles).

In 1880–81 General Walker reported to Government :—" In accordance with my instructions systematic attempts were made throughout the whole work to obtain a greater number of heights than had previously been attempted and these heights were of great assistance to Major Strahan in the delineation of the fair maps. This officer who is an accomplished draftsman has produced some sheets, specially Nos. *27* and *29*, in a style very superior to that of previous work."

In his report for 1881–82 Major H. R. Thuillier, who had again taken over the Mysore Survey from Strahan, wrote as follows :—

" All the surveyors were furnished with the clinometer designed by Major G. Strahan, and observed their heights therewith throughout the work, but the results were more or less unsatisfactory, especially in ground where variations of height were small. I have endeavoured to adhere to 50′ vertical intervals for the contour lines, and to follow out the method of keeping the contours closer to the streams, as introduced by Major Strahan last year in sheets *27* and *29*."

In 1883 General Walker issued an order, in which he explained that a want had been felt of something better than a cardboard clinometer, and that this had led to the invention of six different patterns of clinometer.

Pattern T was intended to be placed *on the surface* of the plane table. Patterns S and R were to be held *in the hand*, elbows being rested on the plane table. Patterns B, W and X were intended to be screwed *to the side* of the plane table. It is *believed* that the letter T denotes " Thuillier's pattern," that S denotes " G. Strahan's " and that W denotes " Wahab's." This is the tradition, but there is nothing on record in any report to explain the origin of these letters. In his report for 1882 Major H. R. Thuillier refers to George Strahan's pattern but not to his own. Thuillier's pattern was found to be the most suitable and was introduced into the Survey. It is liable to an error of 20′ at a distance of 2 miles.

In October, 1881, General Walker asked Major Strahan to take Colonel Campbell's place in the geodetic party, and Strahan's connection with Mysore ceased. As Strahan was in charge of the Mysore Survey for four or five years it is interesting now to follow the criticisms that were passed upon the Mysore maps by the Survey Committee, which was appointed in 1905 to report upon the condition of maps in India.

In his exhaustive report on the Indian maps, dated 1900, the Surveyor-General, Colonel Gore, had expressed himself as follows :—

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"In the year 1874 the topographical survey of Mysore was commenced and was carried through to completion being finished in 1886. It consisted of a survey of the whole country on a scale of 1 inch = 1 mile. The Mysore maps are a most excellent series, and except that they must naturally be getting out of date, they leave nothing to be desired."

The Survey Committee of 1905 condemned large numbers of the maps of India. Of Bengal it wrote that no part of India was worse off. Of Assam it wrote "the maps of Cachar and Sylhet are admitted on all sides to be useless." But of the maps of Mysore the Committee wrote as follows :—"Mysore is more fortunate in its maps than any other province of India ; the survey was commenced in 1874–75 and was completed in 1886. The Public Works Department have given a most favourable account of the accuracy and utility of these maps. They found it possible to lay out a new railway line by the maps. The maps in their opinion could hardly be improved."*

In any community and in any age Strahan would have been in the front rank of map draftsmen. But the specimens of his work, that he has left behind, do not hold their own against modern drawings. Their inferiority is due to three causes ; firstly, in Strahan's day, colour printing had not been introduced, and his maps of Rajputana, Simla and Mysore show outlining, lettering and hill-shading all in black ; secondly, Strahan's maps were reproduced by the inferior process known as photozincography ; thirdly, Strahan never had a sufficient number of values of height at his disposal to enable him to show the forms of hill masses.

Strahan felt rather bitterly about photozincography. "A draftsman," he used to say, "is not allowed to draw what looks well, he has to draw at the bidding of a zincographer. How in the world could I draw a Himalayan map to suit a zincographer ? If you look at my hachures through a microscope, you will see that in my drawing they are sharp crisp lines, but the zincographer has squeezed them out and given them hairy edges."

In 1875 the city of Ajmere was surveyed on the scale of 12 inches = 1 mile. One sheet of this survey, covered entirely with hills rising to 3,000′, was drawn by Strahan himself. Horizontal hachures according to the scale of shade were used. The map is artistic and shows the hill details well. It was specially published for the instruction and use of draftsmen of the Survey of India, as a specimen of hill-shading.

After the 24″ sheets of Simla and Jutogh, 1872-74, had been completed, Strahan reduced them and made from them his well-known drawing of Simla on the scale of 3 inches = 1 mile. This plan is an artistic delineation of a complex Himalayan area. Strahan and Stotesbury

* The Survey Committee, however, reported that the maps of Burma and Baluchistan were the most up to date of the whole country.

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drew the original Simla 24" sheets with horizontal hachures according to a scale of shade: but in his 3" plan of Simla, Strahan depicted the mountains by means of vertical hachures. He threw over the scale of shade and obtained effects of relief by side-light. He much preferred vertical hachures to horizontal. "Horizontal hachures," he used to say, "do not represent any actual markings on the surface of the ground, but vertical hachures indicate the directions in which rain runs off."

One day, after he had retired, he came over to the Survey Office at Dehra Dun to see a large number of Himalayan sheets that had been joined together. The hills had been depicted by approximate contour lines (form lines), and the whole drawing had assumed one flat monotonous shade due to the uniformity of these contours. No mountain relief was apparent, and it was only possible to discover the variations in height by laboriously following out particular contour lines. The surveys had been admirable, the drawings had failed. Strahan's criticism is impressed on my memory because of his reference to General Robinson. "To make these hills stand out," Strahan said, "you must darken the salient points." It was pointed out to him that the contour lines showed the *average* slopes of the ground, and that the slopes round the salient points were not in nature steeper than elsewhere. "Still," he said, "you must emphasize salient points; otherwise the hills are meaningless. Dan Robinson always insisted on this. You will find that even in his published instructions he insisted on the accentuation of salient points."

Now the moment we accept the system advocated by Robinson and Strahan, we throw overboard the principle of indicating steepness of slope by depth of shade. But Strahan's arguments were convincing. "Who wants to know angles of slope in the Himalayas?" he would ask. His view was that we were surrendering the power of making maps realistic in order to show average slopes, which no one wanted to know.

In 1881 the principal geodetic work being undertaken in India was the observation of astronomical arcs of longitude. These measurements had been initiated by General Walker, and the results obtained by Colonel Campbell and Major Heaviside had been utilized by Colonel Clarke in his famous determination of the figure of the earth. The Indian arcs of longitude from Bombay to Vizagapatam and from Mangalore to Madras, being near the equator, had largely influenced Clarke's determination. The flatness of their curvature had led Clarke, firstly, to increase the equatorial radius of the earth, and, secondly, to assume that the equator was an ellipse of small eccentricity with its minor axis terminating in Ceylon. Walker now wanted to measure the arc of longitude from Karachi on the west of India to Moulmein in Burma and to extend the network of arcs over the whole of India. In 1881 Major Strahan succeeded Colonel

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W. M. Campbell in charge of one of the astronomical parties, and in the winter of 1881-82 Majors Strahan and Heaviside carried the longitude operations across North-Eastern India from Agra to Calcutta. In 1882-83 they extended their arcs to Chittagong, and in 1884 to Moulmein.

During the summer of 1885 Major Strahan was in England for six months on duty for the examination of the longitude instruments. He carried out the examination at Greenwich Observatory. The Astronomer Royal provided him with a site and allowed him electrical communication with the standard sidereal clock. Strahan completed his task in time to admit of the instruments being sent out to India in September.

In October, 1885, the astronomical parties assembled under Strahan and Heaviside at Agra. As Heaviside was contemplating furlough I was transferred from the Computing Office to Agra as assistant to the longitude observers. Throughout the winter and spring I was employed with them in extending the arcs of longitude to Multan, Peshawar, Amritsar and Dehra Dun.

My two chiefs had been trained in different schools. Colonel Heaviside had been a geodetic observer from the start and had been grounded in the geodetic school of patience and accuracy. Mr. Hennessey used to say :—"Observers are born, not made, and Heaviside is a born observer." Colonel Strahan had passed many years of his life in rapidly extending triangulation and topography over Rajputana, where he had never been able to slacken speed. He was an able astronomical observer, but he brought the ardour of the Rajputana triangulator into the astronomical observatory, and his impetuosity was a constant source of perturbation to the aged astronomical recorder, Babu Harsahai.

Heaviside used to like to arrange his stars three minutes apart so as to have plenty of time. Strahan thought that one minute was ample. When we were working at what Strahan called "a slow programme," with three minutes' interval between stars, he so disliked waiting that he would keep some computations by him and take them up while sitting at the telescope during each pause.

One of the principal difficulties of longitude work was the liability of the electrical apparatus to stop working, owing to some interruption on the telegraph line connecting the two longitude stations. Whilst the observer was engaged upon star observations in his tent, something would go wrong with the line wire or its relays or with the recording apparatus, and all the star observations would be wasted. Each of the observers had trained an intelligent tindal to watch the pens of the electric recorder and to rush from the telegraph office to the observatory tent to give instant warning when anything was wrong. Heaviside used to instruct me to receive these warnings serenely, to avoid being flustered in the observatory, and not to be

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put out by the thought that the stars would not wait till the electric connections had been restored. Strahan used to deal with these interruptions differently. He would dash at 20 miles an hour from the observatory tent to the telegraph office, rapidly test the connections, signal along the line and dash back in order to save as many stars as possible. His tindal was an excellent Mahratta named Ethu. It was Ethu's business to run to the observatory tent and to warn Strahan whenever the electric recorder was failing. Ethu however used to hesitate to break his bad news, although time was everything. He would stand outside the observatory tent and cough gently. Strahan had got to know the meaning of this cough and directly it occurred he would vanish from the tent.

During the winter of 1885–86 Strahan introduced a new method of computing azimuths, and he designed a new computation form. He showed the form to me at Multan, and asked me to test it. Colonel Heaviside said to me, "Strahan will be so pleased with this new form that he will insist on doing all the computations himself. He will not let us touch them. He will be made very happy." This proved to be true. I used to see Strahan computing away for hours at his azimuth form, and he would at intervals say :—"This form answers splendidly," or "this form saves nine-tenths of the work," remarks with which his colleagues agreed.

In 1886 the Government decided to have a topographical survey made of the Nicobar Islands, and Major Strahan had to abandon the longitude measurements in which he delighted and to undertake the Nicobar Survey. During 1884-86 Capt. Hobday had made a survey of the Andaman Islands, and on his departure for furlough in May, 1886, he handed over charge of the Andaman Survey Party to Strahan. During the summer of 1886 Strahan had charge of both the longitude work and of the Andaman mapping. In November, 1886, Strahan embarked with his party for the Nicobars. Two of the Indian marine steamers, the *Kwangtung* and the *Nankauri*, with all their boats were placed at Strahan's disposal, and a large number of convicts were attached to his party. As the survey operations were sanctioned for one season only, and as all work had to be completed within six months, some departures from the usual practice of surveying were necessary. There was no triangulation ready, and there was no astronomical elements, upon which to base triangulation. Strahan had therefore to arrange to carry out the detail survey, the triangulation and the astronomical basis for the triangulation, all simultaneously. Before Major Strahan left for the Nicobars, I happened to be living with him. I was particularly impressed with his complete independence of textbooks. He was aware that in the Nicobars he would have to observe for longitude, latitude and azimuth, to measure base lines, to make tidal determinations, but I never knew him consult a book. He had so intimate a knowledge of all the various operations, that a

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textbook was unnecessary. The work required to be done in six months was the following :—

(1). An accurate survey of the coast lines.
(2). A correct determination of the positions of the several Nicobar Islands on the earth's surface.
(3). As much topographical detail of the interior of the islands as could be obtained.
(4). A large scale survey of the convict settlement at Kamorta.

Strahan found that there were in all 20 islands ; of these the area of Great Nicobar was 376 square miles ; nine of the islands had areas less than 1 square mile.

The longitude of Port Blair in the Andaman Islands had been determined from lunar observations in 1861. This determination Strahan now accepted, and he measured the difference of longitude between Port Blair and his Nicobar station by means of chronometers, which he tested himself by star transits. He observed also for latitude and azimuth, and he measured base lines with bars of teak. He thought it best not to level his base-line bars but to measure their inclinations, and he invented a special device for doing this. He carried traverses round the coasts of all the islands by means of the subtense bar method which had recently been invented by Colonel Tanner. Strahan's theodolite and subtense bar had frequently to be set up in the sea with the spray dashing over them, and the bar was often partially obscured by the breakers of the never-ending swell. The following extracts are taken from Strahan's report :—

"On December the 4th, heavy rains set in, and it was impossible to proceed with the verificatory measurement of the base. I therefore commenced the traverse of the island of Nankauri. By December the 13th, the swamps had sufficiently dried up to enable me to carry out the second measurement of the base. On December the 15th, I left Kamorta for the Island of Kar Nicobar with Mr. Keating, to start him on the coast traverse. I left him there on the 17th, and then steamed round the island of Batti Malv to ascertain, if it were possible to land on it, as it would be necessary to fix its position by astronomical observations. I then returned to Kamorta and finding the observatory ready, I erected and adjusted the transit instrument. On the following day I completed the coast traverse of Nankauri Island. From December the 28th to January the 5th, I was engaged in observing transits at Port Blair and at Kamorta with a view to determining their difference of longitude. The rest of January was occupied, partly, in observing the latitude at Kamorta and partly in traversing the coast of the island, which proved a difficult job. It was rarely possible to land from the boats direct. The only practicable method was to anchor the boat outside the surf, and then either to swim or wade ashore. Except when the rollers came in, the water was only 4′ deep and the men could stagger along, but the surf went

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often over their heads to the detriment of my theodolites and plane tables. This process had often to be repeated 10 or 12 times a day, and for days together not one of the party ever had a dry thread on him. Five times my boat was completely capsized in the breakers.

"I carried the triangulation across St. George's Channel which divides the Great and Little Nicobars. I succeeded in landing on Batti Malv Island and observed the sun there for latitude. I then proceeded to Kar Nicobar and secured star observations for latitude the same night. In order to get mean sea level I made a series of tidal observations at Kamorta.

"The Nicobar Islands are at such distances apart, that their shores are concealed from one another by the curvature of the earth; this necessitated more astronomical work than would otherwise have been required, as in many instances the triangulation could not be extended from one island to another."

The following extract is from the Surveyor-General's (Sir H. R. Thuillier's) report for 1887 :—

"The survey of the Nicobar Islands presented exceptional difficulties. Much credit is due to Colonel Strahan for the ability, readiness and resource, which he brought to bear on the undertaking, the conditions of which were entirely different from those met with in India."

The following inscription was subsequently erected on a stone at Kamorta :—

"*Great Trigonometrical Survey.*—The position of this stone was found from observations made by Colonel G. Strahan in 1887 to be north latitude 8° 2′ 21″·03 and east longitude 93° 31′ 55″·05."

On the completion of the Nicobar Survey in 1887 Strahan resumed the longitude operations, and in conjunction with Colonel Heaviside observed the Cape Comorin arcs. In 1888 he succeeded General Haig, as the Deputy Surveyor-General in charge of the Trigonometrical Branch of the Survey. Haig did not retire till 1889, but he did not return to duty after taking furlough in 1888.

Strahan never took kindly to administrative work, even when he was officiating as Surveyor-General. He was essentially a man of action. His temperament compelled him to constant action. He liked to be taking observations or to be improving instrumental designs. He had not the patience to study and classify results, or to discuss their meanings as Walker had done. His idea of work was construction, observation, and drawing. As an administrator he seldom went round the observatories without taking some share in the practical work going on. He could not stand by and look on at others. His assistance was always welcomed, never resented; he joined in, not to put others right, but because he loved the work. When an explorer came in from Tibet, Strahan liked to get hold of

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him and to draw the map himself. He rarely went into his drawing office without turning draftsmen out of their seats and adding to their maps himself, and he would spend hours together in the workshops watching the construction of some new instrumental attachment of his own design.

Strahan was the 7th Superintendent of the Great Trigonometrical Survey. His predecessors had been

Colonel Lambton,* 23rd Regiment	1798—1818
Colonel Sir George Everest, Bengal Artillery	1818—1840
General Sir Andrew Waugh, Bengal Engineers	1840—1861
General J. T. Walker, C.B., R.E.	1861—1883
Mr. Hennessey	1884
General C. T. Haig, R.E.	1884—1889

The characteristic feature of the Trigonometrical Survey has been the unbroken continuity of its policy. Its methods, though approved by Airy, Stokes, Clarke, Helmert and Darwin, have been at times derided as hyper-accurate, unpractical and slow. But nothing has turned it from its course. The Superintendents before Strahan had been professional geodesists. It had been no effort to them to maintain a policy with which they were in hearty sympathy; but Strahan with all his love and knowledge of astronomy was first of all a man of action. It could not have been otherwise.

All the early years of his professional career had been passed in strenuous and rapid topographical work. They had impressed upon his mind a practical bent, which led him occasionally into conflict with the old geodetic traditions. Geodetic observers will spend much time in order to avoid remote risks of error. They will argue that the degree of accuracy cannot be judged from present requirements only, for future discoveries may at any time add fresh interests to old determinations; and they will make their observations very refined, in order to have a reserve of accuracy, in order to have a geodetic equivalent for what engineers call their factor of safety. These were points on which Colonel Strahan was not always in agreement with his executive officers. What degree of accuracy is necessary, what degree is desirable? Some of his ideas were foreign to the Computing Office at Dehra Dun. He would at times give vent to opinions expressing doubts, not only of the utility of geodetic accuracy, but even of the reality of it:—

"Walker and Hennessey," I have heard him say, when he was

* Selected, when a junior officer, on account of his knowledge of the stars, to lead Sir David Baird's column during the night preceding the assault on Seringapatam.

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speaking of his predecessors, "were always fighting over the ninth place of decimals, and they were both probably wrong in the seventh."

Although Strahan was not in accord with the old school, whose motto had been, "accuracy before speed," and although his impetuosity occasionally led him into difficulties, he was an enthusiastic Superintendent and most loyal to his predecessors. No one could have been more strict in maintaining the traditional accuracy of the work; whatever may have been his personal opinions he relaxed no rule of his predecessors. When in 1888 Upper Burma was annexed to India he cordially supported the policy of Sir Henry R. Thuillier and of General Haig to cover the newly-acquired territories with a gridiron of first-class triangulation, a policy that had met with unexpected opposition.

As a computer Strahan was accurate and rapid, but his impetuous temperament led him to carry out computations on odds and ends of paper instead of the recognized forms, and far from having each computation done in duplicate by an independent computer, he would complete his own computations and then check them all himself.

W. H. Cole, the Cambridge Mathematician, was in charge of the Computing Office at Dehra Dun, and having for years been the colleague of Walker, he had great influence with Strahan. One day, after Cole had retired, Strahan received a copy of a paper by a Prussian geodesist on the subject of the retardation of the electric current in telegraphic longitude observations. This was a subject which Strahan had studied, and he took exception to the Prussian paper. With Strahan a paper was either right or it was wrong. I once heard a friend of his say "George Strahan only deals in superlatives." Strahan wrote a note to refute the Prussian formulæ, and dealt in it with great numbers of figures. Although he had a Computing Office at his elbow, he did all the computations himself, and in his own impetuous way he checked them himself and published his paper. The Prussian Institute made no reply, but years afterwards when Colonel Lenox-Conyngham and I were at Potsdam, the Director of the International Geodetic Association took us into his library and solemnly pointed to Strahan's paper.* Strahan had made a slip in his calculations which had vitiated his results. On its being pointed out he at once recognized his mistake and it was a great blow to him. It was more than a personal blow, for it was a vindication of the old geodetic school of Walker.

As Deputy Surveyor-General at Dehra Dun, he took up again the investigation of the errors of the longitude arcs, and he designed and made a vertical collimator consisting of a telescope floating in mercury. He also designed a new pattern of sundial for use at our

* It had been published by Colonel Strahan in Vol. XV. of the *History of the Great Trigonometrical Survey of India.*

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tidal observatories. He had studied the subject of sundials, and there is a stone sundial of his construction now standing in the compound of the Survey Office at Dehra Dun. Strahan's pattern of metal sundial was specially designed for tidal observatories at places like Minicoy, Mergui and Muscat, where no reliable time is obtainable. The difficulty with the sundials of the usual pattern was that the shadows they cast were not sharp; there was a penumbra, and it was not possible to say exactly where the edge of the shadow really began. This penumbra is of course due to the sun being a disc instead of a point of light; the uncertainty in time amounted to two minutes, and this was too large for the tidal observations. Strahan met the difficulty by introducing a gnomon with a narrow slit. The sun shone through the slit and caused a thin line of light to fall on to the dial plate instead of the usual shadow. The centre of this line of light could, in spite of its penumbral edges, be estimated with considerable precision. Strahan's pattern of tidal sundial is still in use.

In 1894 Colonel Strahan retired from the service of Government. To the Survey of India his enthusiasm has proved of permanent value, for it has caused enthusiasm in others.

Not having known many professional artists I feel diffident in referring to Strahan's powers as a landscape painter, but they were certainly extraordinary. He told me that when he was fifteen, his mother gave him Ruskin's *Modern Painters*. His father thought that the book was too old for a boy. The gift, however, proved a happy idea, for it remained his inseparable companion for life. "That book," he would say, "has taught me to see nature; all I know of nature and art I have learnt from it."

Strahan used to make rapid sketches from nature and then convert them into larger pictures in his studio. When out of doors, he would always be studying nature. "One's memory," he used to say, "ought to be a storehouse of facts." He would try and learn by heart the intricate forms of clouds and hills and trees in fleeting effects of light. In the rains, he would watch mists for minutes at a time, and would then close his eyes to test whether he could remember their forms and gradations. When once they were fixed upon his memory they were always available for insertion in subsequent pictures.

Although he was a fine draftsman and could use his colours with skill, he excelled mostly in composition. His powers of composition were wonderful. I have walked along Himalayan paths with amateur and professional artists, and I have always heard from them the same complaint:—"This scenery is magnificent, but I can find no subject for a landscape: either there is no suitable foreground, or the foreground is too sharply detached from the distance. I can get no lines that lead into the picture." Strahan alone never made such a complaint, and never found any difficulty. He would see subjects for

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landscape everywhere. I once acted as the secretary to a painting exhibition in India and I came to know the exhibitors. Among the latter were two professionals, a Mr. and Mrs. W., who had studied in Paris and had exhibited at the Salon. These professionals pointed out to me how full of faults Strahan's pictures were, how conventional they were, and how carelessly the foregrounds were drawn. I said to the lady professional one day :—" You and your husband are always finding fault with Colonel Strahan's work, and yet whenever I come into this exhibition you are both looking at his pictures." She said to me :—" That is true. The reason is this; although Colonel Strahan is no draftsman, and no colourist, yet he is a poet : all his paintings are poetry." One morning Strahan came into my office and said :—" Who do you think have come to my studio this morning and asked me to give them lessons ? Mr. and Mrs. W. ! They say they want me to teach them composition."

For 48 years Strahan exhibited at the annual exhibition at Simla. I do not think that he ever failed to win a prize. On three occasions he won the Viceroy's prize, and on other occasions he won the Commander-in-Chief's medal. He took a great deal of trouble in forming sketching clubs for instruction and in getting up picture exhibitions, and many successful amateur artists owe their initiation in landscape painting to him.

Strahan's great power lay in the choice and arrangement of his subjects. In my desire to learn the principles of composition I have noted questions down to put to Strahan. He answered me always with characteristic readiness and clearness, but I never learnt his secret from him. It was the secret of genius, and he could not impart it. I never discovered how it was that he could always find an endless number of poetic subjects, not only among Himalayan snows, but in the deserts of Rajputana, in the jungles of Mysore, on the banks of the Hooghly, in Devonshire, Norway and the New Forest.

His wonderful powers of composition were to some extent his undoing as a painter. His mind was an unfailing well of artistic ideas, that he could not repress. While at his easel painting a landscape of snowy mountains, an idea would strike him of mists clinging to hillsides and partially obscuring the deodars. He would hastily finish off the foreground of his picture in order to commence on another.

Strahan's pictures were criticized, but they sold readily and they fetched high prices. Other artists may have been more accurate and more careful, but no painter has touched the Anglo-Indian public so profoundly as George Strahan. By means of his paintings he has taught that public to appreciate the poetic beauties of Indian scenery. He has handed on to them the lessons he learnt himself from Ruskin.

Strahan was an enthusiastic violoncellist and he was the promoter

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of the Philharmonic Society of Mussoorie and for many years its president and manager.

After Strahan retired in 1894 he settled in Dehra Dun and used to spend his summers in Kashmir, in mountain climbing and in exploring the snows. Mrs. Strahan shared his fondness for mountain scenery and for camp life, and their enthusiasm for Kashmir seemed to increase after every trip. Although he was retired from the Service his life was one of ceaseless activity. In 1898 he went to Bengal to observe the total eclipse of the sun, and some years later he joined a party of the Royal Astronomical Society, and went to Norway for another solar eclipse. In March, 1910, Colonel and Mrs. Strahan left India for good; he was then hale and hearty. He died at Hampstead on January the 7th, 1911, at the age of 71. He leaves a widow, two sons and two daughters.

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REVIEW.

MANŒUVRE ORDERS.

By COLONEL F. TRENCH, C.V.O., D.S.O. Tenth revised edition (1911), by MAJOR B. M. BATEMAN, R.G.A.—(W. Clowes & Sons, Ltd., 23, Cockspur Street, S.W. Pp. vi. + 115, and 18 pp. on pocket card. $3\frac{3}{4}'' \times 5''$. Price, 2s.).

THE first edition of this little book was published in 1898. What to the British Army were then new ideas, requiring quotations from German sources to recommend them, are now embodied in our own regulations, and subsequent editions have accordingly been revised to bring them into conformity with the official books. Such revision is rarely entirely satisfactory; had the first edition appeared after, instead of before, our present *Field Service Regulations* and been based on them, various points would probably have been put differently and some errors avoided in the examples.

The first chapter deals with "General Principles," *i.e.* remarks on orders, points to be considered in writing them, etc., the main points of which are now embodied in *Field Service Regulations*. The second chapter describes a method of obtaining practice in writing orders by means of "Map Staff Rides." Chapter III. contains tables and data of establishments, transport, road spaces, camps and billets, and the official abbreviated titles of regiments. These data are taken from *War Establishments*, the *Field Service Regulations*, the *Field Service Pocket Book*, and other official publications. Chapters IV. to VIII. give outlines and examples of orders for marches, attack, defence, convoys, halts, bivouacs, etc. Chapters IX. and X. contain specimen orders for the defence of a locality by an extemporized volunteer force, and Martial Law Regulations. The eleventh chapter gives outline orders for the passage of a river and for a landing. Chapter XII. gives examples of the standing orders required at manœuvres and on service. Accompanying the book is a waistcoat-pocket card of outlines for use at manœuvres and war games.

The principal point that strikes one on looking through a book of this kind is, of what use is it? If the reader knows the contents already, is the book of any use to him? If he does not, would he not do better to study the official books on the subjects dealt with? To the first question it may be answered that the book contains, in a form handy for reference, information scattered in various places in several different books. To the second the reply is that the book does not profess to be a substitute

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for the official books, but only to illustrate them. The *Field Service Regulations* give excellent instructions on writing orders, but they are all in general terms; the practical application of the instructions to definite conditions can best be shown by examples. Without examples to illustrate the regulations a beginner finds many minor, but none the less real, difficulties. The fact that the book has reached its tenth edition shows that there is a considerable demand for it.

While examples are undoubtedly of great assistance, the ones given do not entirely agree with the precepts they are intended to illustrate. It is surely superfluous to put in orders that an advanced guard "will protect the advance of the main body," that the main body "will follow the advanced guard," and that the "Brigade Signal Officer will establish and maintain signalling communication between units and G.O.C." All these appear in a single example of march orders (p. 47). When the commander of an advanced guard or column is named, the troops allotted to him should be detailed in order of seniority of arms, not in order of march (pp. 49, 54); the words "the head of" should not be used when naming the time at which a body of troops should reach or pass a given point (pp. 47, 50, 54); an officer to command the transport should always be named (*Field Service Regulations*, I., 28, 5).

In both the examples of attack orders, also, the author after detailing the artillery adds "Target: the enemy's artillery." *Field Service Regulations* say "Artillery commanders must closely watch the advance of the infantry, and direct their fire against what is, for the time being, the most important target, always remembering that the object of their fire is to assist the infantry advance." If the defender withholds his artillery fire (as the author evidently expects he will—see his examples of defence orders), to name the target thus in attack orders reduces the attacker's artillery to the position of spectators.

The above are only some of the more obvious points to which the author might well turn his attention; and it is to be hoped that in the next edition they may receive consideration, so that the officers who find the book useful may be able to rely upon the examples as being in accordance with accepted practice, based upon the official books.

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NOTICE OF MAGAZINE.

RIVISTA DI ARTIGLIERIA E GENIO.

April, 1911.

ON THE MOBILITY OF ENGINEER TROOPS AND OF THE METHOD OF LIGHTENING THEIR TOOLS AND EQUIPMENT SO AS TO RENDER THEM MORE FIT FOR SERVICE IN THE FIELD.—Whilst in France the question of the reorganization of engineer troops is being discussed, Capt. Winkler, of the 20th Battalion of French Engineers, has published in the March and April numbers of the *Journal des Sciences Militaires* a valuable article on the above-mentioned subject.

Taking into consideration the present state of the organization of the French Engineers, and after examining the causes which do not fulfil the exigencies of modern warfare, the author points out certain improvements in the instruction of the troops, in the employment of officers and men, and especially in the formation of the engineer parks and equipment with a view to increasing the rapidity and efficacy of this arm on the field of battle.

Capt. Winkler commences his article with some general considerations on the duties of sappers in the field, and on the tactical instruction of engineers. With regard to the first of these points he premises that the means at the disposal of the artillery and infantry for removing obstacles to their advance are generally insufficient, and the author dwells on the necessity for special troops having special technical training and being equipped with suitable tools, instruments, and material.

With regard to the technical instruction of the engineers, the author says that it should be such as to teach them at all times to be conversant with the requirements of the troops in their vicinity, to act in accordance with the intentions of the officer in command, and to render devoted assistance to the other arms in the shortest time and with the greatest efficacy.

The simple instruction in fortification, which it is necessary to give to the officers and troops, is not sufficient to qualify them for those concrete situations which occur in actual war and for which there is need to find a true and ready solution. In addition to the instruction in fortification, there should be exercises of such a nature as to render them proficient not only in technical instruction but especially in tactics.

The author then proceeds to examine these questions, and to consider separately those that refer to the organization and *personnel* of the engineers, or relate to the material and parks of the companies.

Organization and Personnel.—The duties of companies of engineers attached to divisions are always very numerous, complicated, and invested generally with a character of urgency, so much so that one company is not sufficient to assure a continuous and efficacious service, and it is necessary to assign *two companies of engineers to each division of*

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infantry. In all great modern armies the tendency is to increase the pioneer troops; the Japanese have a battalion of pioneer troops for each infantry division; in the German Army the new law brings the proportion of engineer troops from 4·5 battalions of pioneers to 100 infantry battalions.

In view of the breaking up of engineer companies, either for the execution of work or for tactical reasons, it is necessary that there should be an adequate number of subalterns for each company of engineers. These should in the author's opinion be not less than four, all mounted. The necessity of sufficient means for the transmission of orders and reports also requires that there should be *three cyclists and one mounted sapper.*

For carrying out certain duties at short distances from its own unit also, such as reconnaissances, passages of rivers, etc., a small group of cyclists should be assigned to the mounted sappers under the command of a non-commissioned officer, so as to co-operate not only with the officers of the reconnoitring parties, but also to execute any works preparatory to the arrival of the main body of the company.

In view of the companies being broken up for various works, the officers and non-commissioned officers of engineers should also all be trained as signallers, and each section should have two sapper signallers. The telephone should also be used and this can be done by means of four telephonists per company, equipped with two micro-telephonic stations and 3 or 4 k.m. of line.

The following dispositions are recommended:—

(1). *In Co-operation with Infantry.*—(*a*). The infantry should themselves excavate the trenches, which they are charged to defend, with their own tools aided by those from the engineer parks, and should organize the resources and the obstacles at their disposal. The engineer troops should co-operate with the infantry in constructing the trenches with strong profiles, and in undertaking all works that require special technical knowledge.

(*b*). With the precision and rapidity of fire that now obtains, the concentration of fire becomes exceedingly damaging to works with large superficial area and strong profiles, as these offer an excellent target to the fire of explosive shells, while lightly constructed trenches are far less exposed.

(*c*). Engineer troops should assist in the construction of defences at supporting points of a position, but it cannot be admitted that this is one of their chief duties. The duty of defending a point of support rests mainly with the infantry to whom the engineers bring their technical resources.

(*d*). In the attack of villages, woods, salient points of ground, etc., if obstacles impede the assault, it is necessary to have resource to the engineer detachment equipped with explosives and proper tools, to open a passage for the infantry.

(2). *In Co-operation with Artillery.*—The co-operation of artillery and engineers on the battlefield is less frequently required than that of the engineers and infantry, and would only happen in the destruction of obstacles that may impede the march, in the passage through woods, and the felling of trees to take up a position. Such co-operation is only

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useful when the work can be done with the greatest rapidity, and in such cases the light groups of cyclists and mounted sappers would be of great service.

Dispositions for Material and Company Parks.—Portable spades or shovels should be used by the infantry for the excavation of trenches which have not a greater depth or profile than those required for fire when kneeling. For greater depths, the French infantry use portable tools of the same pattern as those used by the engineers, and which are carried on light wagons in the proportion of two to each regiment. For more important works the troops make use of the tools from the engineer companies or those of the engineer parks of the army corps.

The portable tools of the French engineers are allotted to each company as follows:—128 excavating tools (64 picks, 64 shovels), 72 cutting tools (billhooks, saws, small picks, scissors, etc.). These are distributed among the sections so that each can be employed independently on various works. This allotment of tools both as regards quantity, etc., is sufficient for all works of the first urgency likely to be required by a company on the battlefield.

The park of the sappers and miner companies of the French Engineers comprises 239 tools, of which 94 are excavating tools (64 shovels, 30 pick-axes), and 145 are cutting tools (knives, billhooks, scissors, etc.). This is a sufficient allotment for fortification work, and demolitions which may occur in a campaign, but the patterns of tools for the park are too heavy. With regard to explosives the park for a company contains 194 k.g. of mélinite, a quantity which is much less than the 400 k.g. carried in the German parks of pioneer companies.

The author goes on to say that the wagons for the company parks in the French Engineers are too heavy. It would be advisable to lighten these wagons, and also to distribute the material in these carriages so that each company of engineers can perform its duties in the least possible time. The adoption of light carriages with two wheels is recommended, to allow of the breaking up of the engineer companies into detachments, a question intimately connected with that of the distribution of material. Arrangements should be made for the breaking up of the companies into four sections or subdivisions, so that four wagons would be requisite, each containing the necessary tools for the men of the sections.

With regard to explosives, as their use varies in many cases they can conveniently be divided into two allotments—one of sufficient quantity for the small demolitions which are commonly required on the battlefield, the other forming the load for a special carriage for more important demolitions. This latter carriage should contain from 120 to 130 k.g. of mélinite and the miners' tools.

With regard to the tools for bridging purposes, he recommends that one special carriage should be retained for each company. There would then be six wagons per company—four for the section, one for the explosives, and one for bridging materials.

The wagons should not have a greater weight than 1,100 k.g. each, they should have two wheels, and be drawn by two horses, made up as

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follows:—Empty wagons, 470 k.g.; tools and materials, 360 k.g.; 30 bags (each 8 k.g.) 240 k.g.; total, 1,070 k.g.

The wagon for explosives should weigh 1,020 k.g., and that for bridging material 1,170 k.g.

The following would be the advantages of a park for a company of engineers so arranged:—(1). It would always be able to follow the company and with the assistance of a few men could be taken over small ditches or embankments. (2). The carriages could always proceed quickly to any given locality, and in case of being left behind they could be used singly with the sections of companies for urgent works. (3). With the aid of the section carriages it is possible to lighten the haversacks carried by the men of the company, leaving them free to work as sappers. (4). In whatever manner the companies might be broken up, the various sections could be followed by the carriages.

Finally the author treats of the question of *light bridging parks* for sapper companies, and states that, notwithstanding the willingness of the men, it is not always possible to construct useful bridges across rivers or water-courses by local resources. It is necessary that the engineers should have with them the requisite materials for bridging, and such as can readily be used on the battlefield. This material should be such that it would be possible to construct with it a bridge of about 20 m. in length and that with two such units a bridge of 40 m. could be made. The wagons for this bridging material should be sufficiently light and mobile to be able to run quickly on any kind of roads.

For the various parts of the bridges, boats of metal divisible into two parts are recommended of a length of 4 m. to 4·5 m. each, and the length of the planks for the boat bridges should be 5 m. The wagons for the transport of this material should have four wheels and should be drawn by four horses, they should not weigh more than 500 k.g. when empty, or 1,500 k.g. when loaded. Nine wagons with four horses each would be required for the whole. The weight of each wagon would amount to 1,530 k.g., viz.:—Empty carriage, 500 k.g.; load of material, 750 k.g.; 3 men with equipage, 280 k.g.; total, 1,530 k.g.

With this park material 21 metres of bridge for the passage of troops can be constructed, for infantry in file, cavalry in single file, and for sections of mitrailleuses. A division having then two companies of engineers will then have the means of crossing for 42 m. of bridge.

The strength in men and horses for a sapper company of engineers assigned to an infantry division is then given as follows:—

(*a*). Companies:—1 captain and 4 subalterns mounted, and 245 N.C.O.'s and men, viz., (1), 16 sergeants, 16 corporals, 16 head workmen (*capi operai*), 165 sappers, 8 signallers, 4 telephonists, 3 cyclists; (2), 1 sergeant, 1 corporal, 1 head workman, 14 sapper cyclists and mounted men forming a light detachment.

(*b*). Company park commanded by an officer:

8 drivers; 14 horses (1 saddle and 1 reserve); 6 wagons.

(*c*). Park for light bridging:

23 drivers; 41 horses (3 saddle and 2 reserve); 9 wagons.

E. T. THACKERAY.

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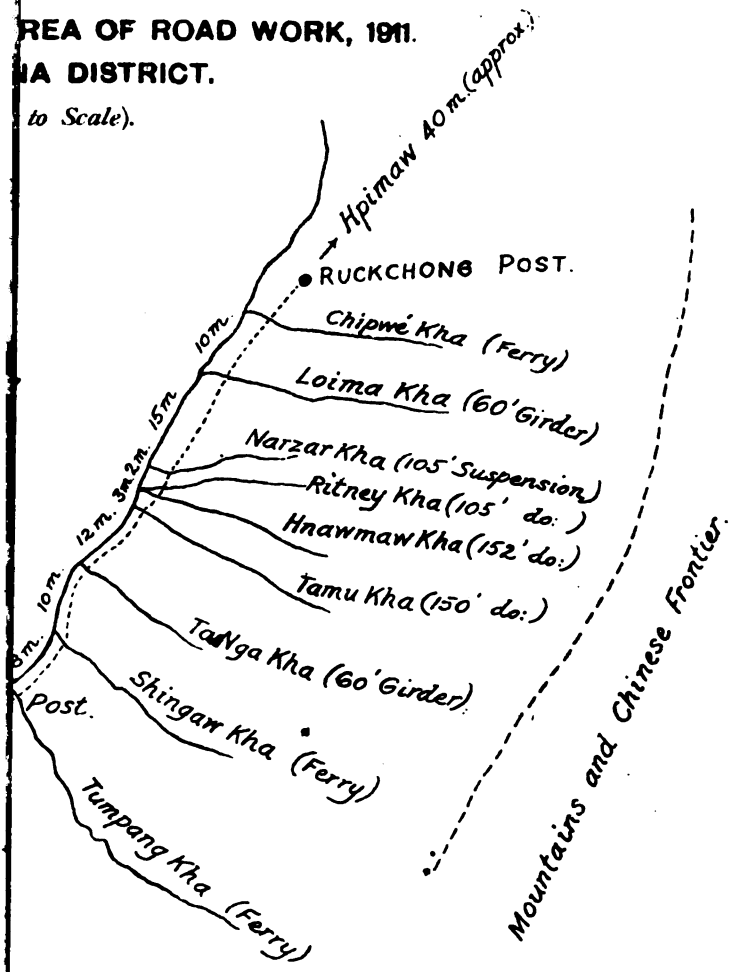
REA OF ROAD WORK, 1911.
IA DISTRICT.
to Scale).



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REPORT.

DURING 1910 241 Officers received treatment. 174 Operations were performed.
OFFICERS ADMITTED :—Royal Navy and Royal Marines, 33; Royal Indian Marine, 3; Royal Artillery, 24; Royal Engineers, 20; Cavalry, 9; Foot Guards, 1; Infantry, 74; A.S.C., 1; R.A.M.C., 2; A.V.C., 4; A.P.D., 2. INDIAN ARMY—Indian Army 7, Cavalry 11, Infantry 46, I.M.S. 1—65.
Staff, Unemployed, etc., 3.

TOTAL—241

Dr. Balance Sheet, 31st December, 1910. Cr.

	£ s. d.	£ s. d.		£ s. d.
To RECEIVED IN ADVANCE IN RESPECT OF ANNUAL CONTRIBUTIONS		202 12 0	By INVESTMENTS	40,699 5 8
,, BALANCE—Viz., Excess of Donations over Initial Outlay and Current Expenditure to 31st December, 1909	43,099 12 0		,, CASH AT BANKERS	3,578 3 4
,, Excess of Current Income over Expenditure ...	975 5 0			
		44,074 17 0		
		£44,277 9 0		£44,277 9 0

Dr. Income and Expenditure Account, Year ending 31st December, 1910. Cr.

	£ s. d.	£ s. d.		£ s. d.	£ s. d.
To RENT, RATES, TAXES, WATER AND INSURANCE		708 1 2	By SUBSCRIPTIONS APPLICABLE TO THE YEAR, VIZ. :—		
,, REPAIRS AND ALTERATIONS TO HOSPITAL ...		512 17 1	His late Majesty King Edward VII.... ...	100 0 0	
,, GENERAL MAINTENANCE EXPENSES—			H.M. King George V....	100 0 0	
Salaries and Wages ...	1,398 0 3		Sir Walpole Greenwell, Bart.	100 0 0	
Washing	272 10 5		Sir E. Cassel, Bart. ...	100 0 0	
Provisions and Household Stores	2,040 18 3		S. Neumann, Esq. ...	100 0 0	
Wines and Spirits ...	67 16 3		J. Larnach, Esq. ...	100 0 0	
Fuel and Light	246 12 0		W. Burns, Esq.	50 0 0	
Clothing, House Repairs, Telephone, and other incidental expenses ...	391 0 4		Lord Burnham	100 0 0	
		4,416 17 6	S. E. Palmer, Esq. ...	100 0 0	
,, SURGICAL DRESSINGS, MEDICINES, PATHOLOGICAL REPORTS, MASSAGE, AND SUNDRY FEES		950 1 7	Sir H. Praed, Bart. ...	10 10 0	
,, BALANCE CARRIED TO BALANCE SHEET		975 5 0	Miss Keyser	100 0 0	
			Sister Agnes	100 0 0	
			Lord Rothschild... ...	100 0 0	
			Alfred Rothschild, Esq.	100 0 0	
			Leopold Rothschild, Esq.	100 0 0	
			C. E. Keyser, Esq. ...	100 0 0	
			Mrs. Livingstone Bruce	20 0 0	
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			Mrs. Bischoffsheim ...	50 0 0	
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			,, DIVIDENDS ON INVESTMENTS		1,870 19 8
			,, SUBSCRIPTIONS AND DONATIONS PER OFFICERS OF THE NAVY AND ARMY AND RETIRED OFFICERS		3,519 5 8
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We have examined the above Statements of Accounts with the books and vouchers of the Hospital, and find the same to be correct.

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U C L. DUPLICATE

THE ROYAL ENGINEERS JOURNAL.

Vol. XIV. No. 4. OCTOBER, 1911.

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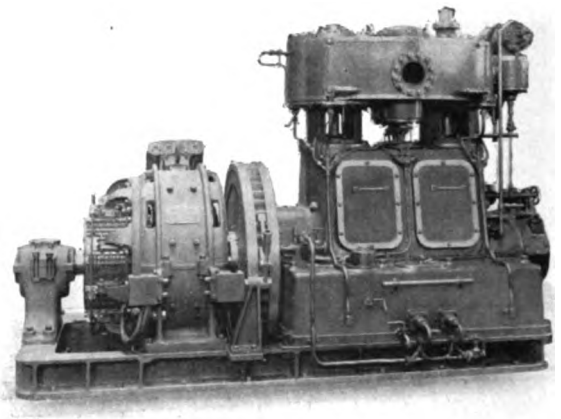

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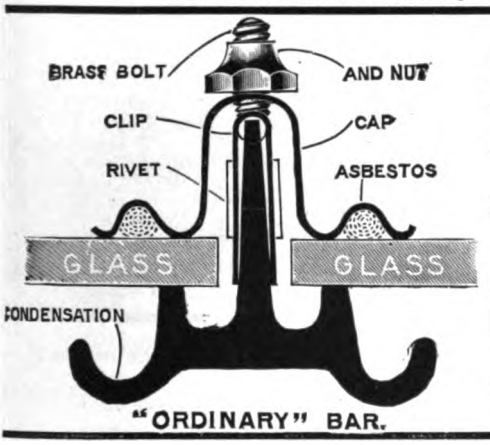

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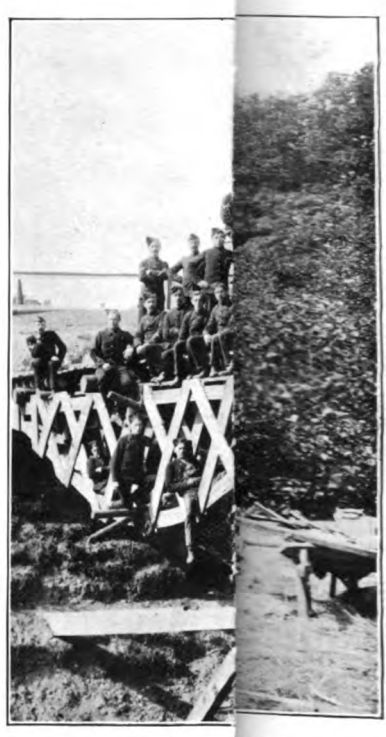

Photo 1.—80′ B[illegible]904.

Photo 2.—57′ Bri[illegible]

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GIRDER BRIDGES FOR MILITARY ENGINEERS.

(Continued).

By Capt. E. N. Mozley, R.E.

PART II.

DETAILED DESCRIPTIONS OF BRIDGES.

1. 51′ Bridge for Cavalry in Single File.

Built at Christchurch Camp in 1899 by Cavalry Pioneers and R.E. N.C.O.'s. Width of roadway—6′, carried on the top of two girders 6′ centre to centre.

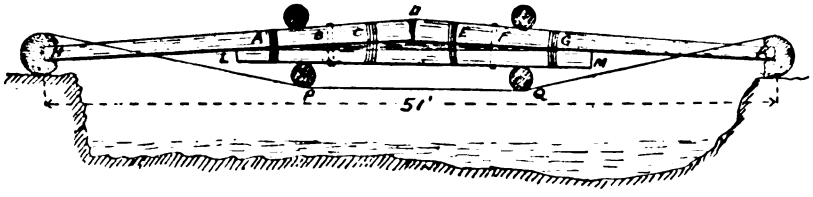

Fig. 5.

Type of Girder.—Each girder was a "fished beam" as in *Fig.* 5.

(*a*). *Description and Method of Construction of Girder.*—Two poles, HD and DK, 5″ at tip, 11″ at butt, were laid butt to butt on cross-pieces, which provided clearance above the ground and eventually acted as rollers in launching. A third pole LM of equal dimensions to the other two was laid alongside them as shown.

LM was lashed to HD and DK with 2″ lashings at A and G and with wire at C and E. (Cordage is preferable to wire as it is easier and quicker to use ; it should be well wedged up).

2″ auger holes were then bored through both spars at B and F and a hardwood trenail, 18″ long slightly larger than the hole, was driven through each. The idea of the trenails was to oppose the horizontal shearing stress between the spars and so to convert them into a single beam of depth equal to the combined depth of the spars composing the girder.

The space at D between the butts caused by the taper of the spars, was closed by a hardwood wedge to resist the thrust.

(*b*). *Method of Launching.*—Each girder was launched separately, being rolled out half-way and then pulled across by a fall from a 15′ sheer legs erected on the far side. It was found that a single girder would not remain vertical but leaned over sideways. There

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would be no tendency to do this if the girders were lifted up into vertical planes as soon as they were built and cross braced to prevent them distorting again. They could then be hauled across together.

(*c*). *Trussing the Girders.*—To strengthen the bridge the girders were subsequently trussed as follows:—Cross-pieces were lashed across at P and Q and other cross-pieces were placed at the ends of the girders at H and K, so that the ends of both girders butted against square seatings on the cross-pieces and were secured by spikes driven through the outside of the cross-pieces. Wire ties of the requisite strength were then passed from H to K under P and Q and made fast. This trussing should take place before launching, in which case men should bear down on the ends of the girder so that on their release the ties may be quite taut.

If however the trussing takes place before launching, it will make the use of rollers difficult unless some expedient such as the following is used:—After constructing, connecting and trussing the girders and before launching, lift them on to two light spars running from P to Q and make fast P and Q to them. These auxiliary spars can then move on the rollers.

(*d*). *Working Party and Time.*—Two R.E. N.C.O.'s and 14 Cavalry Pioneers built and launched the bridge in 13 hours. It would only have taken 10 hours if cordage had been used instead of the wire lashings.

(*e*). *Remarks.*—The deflection at the ends, between H and L and between M and K was considerable. It would probably be best to allow the lower spar LM to continue the whole length, from H to K, breaking joint with the upper spars. The trenails would then be placed near the abutments, where the shearing stress is greatest. Double the number of trenails might be used.

Of course this method of construction does not make a perfect truss, but the type is possible for small gaps where nails are not to be had.

2. 80′ BRIDGE FOR INFANTRY IN FOURS, WITH ONE CENTRAL TRESTLE.

Width of roadway 9′.

This bridge will be treated as two separate single spans, one of 36 and the other of 42′.

(i.). 36′ *Span.*

(*a*). *Description.—Type of Girder.*—Bowstring (bow downwards) (*Fig.* 6).

The girders were placed with the bow downwards for the following reasons:—

(*a*). The straight flange, which is less liable to buckle than the curved one, is thus in compression.

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(β). The girders, when placed, are in a state of stable equilibrium. If the bow were upwards they would need external bracing to keep them upright.

Each top flange consisted of 7 ($\frac{3}{4}$") boards.

Each bottom flange consisted of 8 ($\frac{3}{4}$") boards.

For 3′ at each end the flanges were bolted together through a wedge placed between them. Five $\frac{1}{2}$" bolts were used. The ends were then boxed in by means of vertical boards on each side.

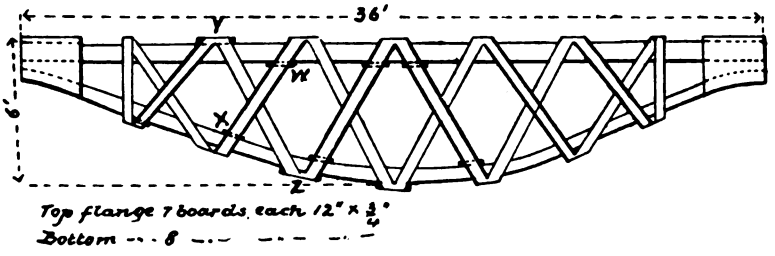

FIG. 6.

The web consisted of a double series of bracing, as shown in the figure. There were 14 braces on each side of each girder. These were not nailed to the boards of the flanges, which were too thin to take the nails, but to pieces, 2" × 12", as at W, X, Y, Z, which were themselves nailed to the flanges. These pieces should be placed inside the flanges for compression braces, as at W and X, and outside the flanges for tension braces, as at Y and Z.

The bracing was of the lattice type, the planks being in pairs on both sides of each girder.

It is necessary to see that compression braces are not forced into a curve between the flanges or they will have a tendency to buckle.

(*b*). *Method of Constructing the Girders.*—The longitudinal section of the girder was laid out on the ground with pickets, which enclosed the flanges. The planks of the flanges were then laid down in lengths, breaking joint, and nailed together with 5" wire nails. The flanges were then bolted together at the ends with $\frac{1}{2}$" bolts and boxed in and then the bracing was nailed upon one side. Then the girder was turned over and the bracing put on the other side.

(*c*). *Method of Launching.*—The girders were hoisted into position by two pairs of sheers, one on each bank, which lifted them up into the air, and, by paying out and taking in the tackle, carried them across and lowered them into position. One pair of sheers had to be a long way off owing to the second span in the bridge ; this made the operation more difficult. A 7" bearing was given on the cap of the central trestle.

(*d*). *Cross Bracing between the Girders.*—It was found that the girders were liable to rock in their seatings owing to wind or traffic. They were therefore braced together with a spar connecting the

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centres of their lower flanges, and two transverse diagonals from the centre of the lower flange of one girder to the centre of the upper flange of the other. This gave complete rigidity.

(*e*). *Time and Men.*—Making girders 6 men 29 hours.

Launching and completing roadway 40 men 6 hours.

(N.B.—The double span caused abnormal difficulties in launching).

(*f*). *Remarks.*—The dimensions of the web planks should decrease from the abutments to the centre; at the former points the compression planks should be 3″ thick to prevent buckling.

(ii.). 42′ *Span.*

(*a*). *Description.—Type of Girder.*—Inverted Queen-post roof.

The two girders were built together on land into one frame and so launched.

Fig. 7 is a longitudinal elevation.

Fig. 8 is the plan of one upper flange.

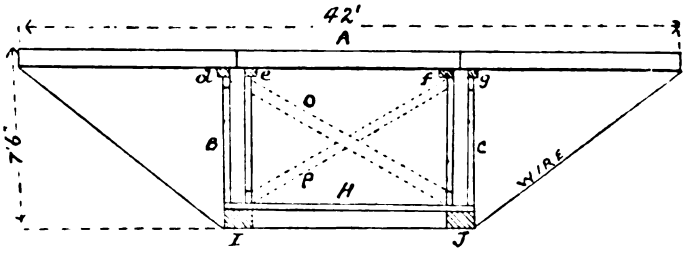

FIG. 7.

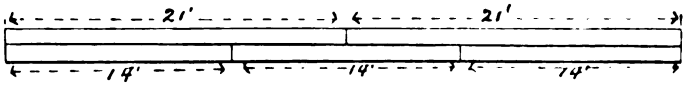

FIG. 8.

Each upper flange A was built up of scantlings 12″ × 6″ as in *Fig.* 8. The spikes were placed all along the beam but most thickly at the joints.

The struts B and C were dogged to A and also secured by transverse pieces *d*, *e*, *f*, *g*, spiked across from the under surface of one upper flange to that of the other.

Distance pieces H were dogged to the feet of the struts B and C.

Distance pieces I and J connected the feet of the struts B and C on one girder to the corresponding points on the other girder.

The usual diagonal bracing, shown in the photograph, completed the structure.

Sizes of Timbers.—Upper flanges, 21′ and 14′ pieces, 12″ × 6″ in cross section.

Struts B and C 6″ × 6″.

d, *e*, *f*, *g*, 6″ × 2″.

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Distance pieces H, I, J, 6″ × 3″.
Cross bracing, 9″ × 2″.
Size of chain, 1½″.

(*b*). *Method of Construction.*—The composite beams forming the upper flanges were put together and then the girders were built upside down. The chain was spiked through the links where it passed under the feet of the struts and was secured to the ends of the beams by a screwed hook of 2″ iron, passing through a hole in the beam and bolted up against an iron plate fitted over the shaped ends of the beams, as in *Fig.* 9.

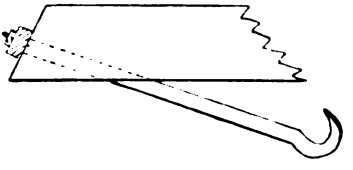

FIG. 9.

Iron plates should not be put under the feet of the struts, as the links of the chain should be allowed to bite into the wood there to avoid the possibility of the links getting bent.

(*c*). *Method of Launching.*—The girder was picked up by the two sheers on either side of the 80′ gap, turned over in the air and dropped into place. This method was a very difficult one and the process of turning the girder over in the air should always be avoided. This girder could probably have been built the right way up.

(*d*). *Time and Men.*—Making girder 16 men 13 hours.
Launching and completing roadway 40 men 4 hours.
(N.B.—The double span caused abnormal difficulties in launching).

This type is not sound, as it cannot, if the bow be downwards, be rolled and slid across, but has to be lifted into place by means of sheers on both sides of the gap, which is difficult for any but small spans. If the bow be upwards, the usual method of launching is possible, but then the roadway has to be carried on the lower flanges, which means a distinctly bigger structure. Nor in such cases is the launching so easy, since the lower flanges have to be raised to reach the abutments on the far side of the gap.

3. 49′ BRIDGE FOR CAVALRY IN SINGLE FILE.

Built at Herne Camp near Christchurch in 1904 by R.E. Launched by R.E. and Cavalry Pioneers.

Width of roadway 6′. Carried on the lower flanges of two girders 9′ 6″ apart, centre to centre.

Types of girder used :—

(i.). Warren. Depth 6′.
(ii.). Plate. Depth 6′.

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(i.). *Warren Girder.*

(*a*). *Description.*—*Fig.* 10 is a skeleton diagram of the girder, which is divided into seven panels, the slope of the braces being 60°. Each panel of the flanges and each web brace consisted of 6″ × 1″ deal planks, the number of planks being written against the member in *Fig.* 10, as is also the nature of the stress to which it is subjected. Where reversal of stress could take place both + and − is shown, the upper sign being the normal one when the bridge is fully loaded or unloaded.

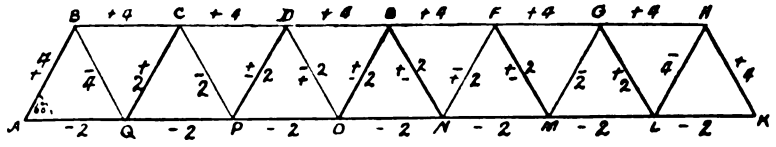

FIG. 10.

Camber.—Each central interval from joint to joint is theoretically 7′, but in order to give a camber each tension member was bored with the auger holes $\frac{1}{8}$″ less than the 7′ centre to centre, and each compression member with the holes $\frac{1}{8}$″ more than 7′ centre to centre.

Joints.—The joints consisted of :—

$1\frac{3}{8}$″ oak trenails at A, B, C, D, O, P, Q.

1″ trenail at E.

1″ iron bolts and nuts at F, G, H, K, L, M, N.

The planks were threaded on the bolts or trenails alternately, *e.g.* :—

At B they were in this order :—A plank of AB, then a plank of BC, then a plank of BQ, then a plank of AB, and so on.

At A they were in this order :—A plank of AB, a plank of AQ, two planks of AB, a plank of AQ.

And it is important that the planks which are most highly stressed should not be on the outside at panel points, in order to allow the bolt or dowel to offer a double-shear resistance to them.

All compression members had their planks braced together at 2′ 4″ intervals with blocks. The planks of tension members were braced together with a block at their centre.

In order to prevent the top flange buckling it was given a width of 18″ at the centre and proportionally at other points.

In order to prevent the trenails or bolts from tearing through the ends of tension members all such members were cut long enough to allow 12″ of overlap beyond the auger hole. (See *photos*).

Cover Plates.—The flanges BH and AK are built up of planks 14′ long (*i.e.* twice the length of each panel). All joints occurred halfway between the panel points, and every alternate plank in each member (*i.e.* 2 out of 4 in the top flange and 1 out of 2 in the

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bottom) was broken in the middle of each panel and connected to the plank which butted it, by means of cover plates. (This involved the insertion of some 3′ 6″ and 10′ 6″ pieces at the ends of the flanges to adjust the joints). Cover plates were 6″ × 1″ planks bolted or trenailed to the main flange planks on each side of the joint, thus making a fish-plate connection. They were 4′ or 5′ long and were fixed to the main planks with 1 or 2 bolts or trenails on each side of the joint.

The bearing stress per square inch is greater in the case of 1″ bolts than of $1\frac{3}{8}$″ dowels, but the latter are the weaker against shear.

The maximum bearing stress on the planks was 1,900 lbs. per square inch.

The maximum shearing stress on the trenails was 900 lbs. per square inch.

In order to obtain uniformity and simplicity, the number of planks in each member and the sizes of the dowels, trenails and bolts connecting them were arranged as in *Fig.* 10 and as detailed in the description. This brought some variation of unit stresses on the various members, which could to some extent be compensated on service by the use of the better material where it was subjected to the greater stress.

(*b*). *Calculations.*—The Warren girder was calculated in the usual way. The maxima stresses on the members, after allowing for the various possible loadings of the bridge, were as follows :—

Web Braces.

AB = KH = + 5,544 lbs.	PD = MF = + 2,466 or − 277 lbs.
BQ = HL = − 5,474 „	DO = FN = − 2,326 or + 277 „
QC = LG = + 3,954 „	OE = NE = + 1,150 or − 1,460 „
CP = GM = − 3,814 „	

Flange Members.

AQ = KL = 2,773 lbs.		
QP = LM = 7,406 „		−
PO = MN = 10,206 „		
ON = 11,172 „		
BC = HG = 5,509 „		
CD = GF = 9,226 „		+
DE = FE = 11,109 „		

The stresses per square inch on planks, after using Gordon's formula for long struts in the case of compression members and allowing for trenail holes in the case of tension members, did not exceed 1,313 lbs. and 1,271 lbs. respectively.

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(ii.). *Plate Girder.*

(*a*). *Description.*—*Figs.* 11 and 12 give the two cross sections of the girder, *Fig.* 11 being that for the central 29′ and *Fig.* 12 that for the 10′ at each end.

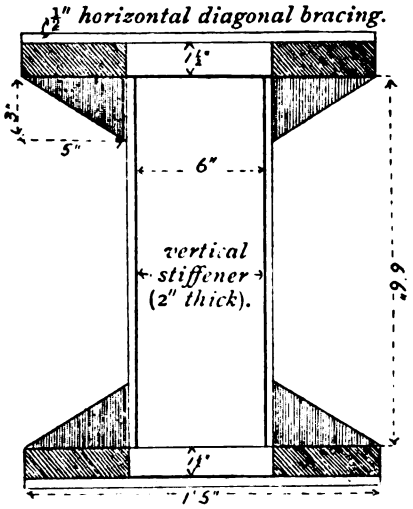

FIG. 11.

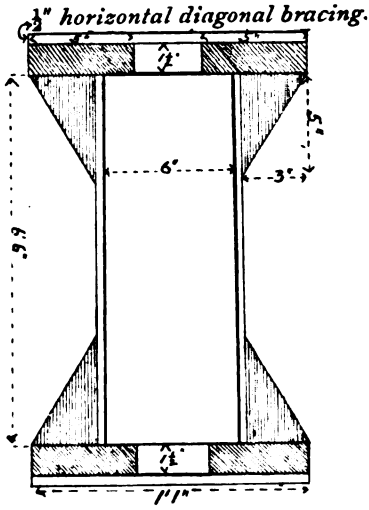

FIG. 12.

Each flange consisted of two triangular pieces, 3″ × 5″. These pieces were placed with the 5″ horizontal for the central 29′ of the girder in order to give greater nail area for the cover plates and to increase the width of the compression flange, and with the 5″ vertical for the remainder of the girder in order to give greater area for nailing the web plates. This is in accordance with the variations of the flange and web stresses respectively. The 5″ × 1½″ planks shown above and below the two triangular pieces in each flange are cover plates transferring the stress at the joints of the triangular pieces.

The two triangular pieces in each flange were in 10′ lengths, each breaking joint with the other and with the piece immediately below.

The web consisted of a double series of 6″ × ½″ planks placed at a 45° slope in a vertical plane and nailed to each upper and lower triangular piece. *Figs.* 13 and 14 show a side elevation of a girder, respectively at the end and at the centre. It will be seen that, while the web planking is continuous at the ends, it opens out towards the middle until the boards are spaced at 2′ central intervals at the middle of the girder. This is in accordance with the decrease of shearing stress towards the centre.

The other series of web planks (not shown in *Figs.* 13 and 14) ran in the opposite diagonal direction.

Vertical stiffeners, 6′ 6″ × 6″ × 2″ placed every 7′ along the girder connected the two series of web planks, which were nailed to them.

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Vertical end stiffeners, 6′ 6″ × 13″ × 2″ at each end of the girder were nailed up against the ends of the flanges and web planks (see *photo*).

A light system of horizontal diagonal bracing, composed of pieces 6″ × ½″ connected the two sides of each flange, above the top cover plates and below the bottom ones.

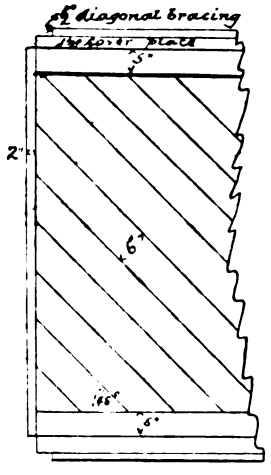

FIG. 13.

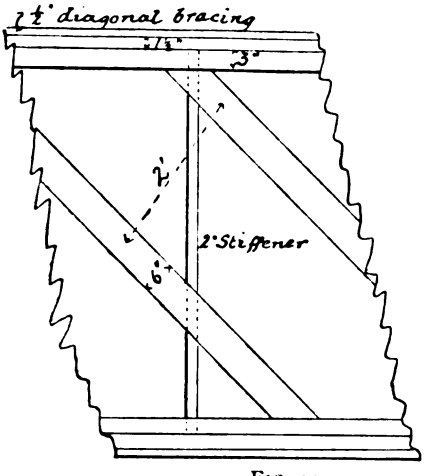

FIG. 14.

The web planks of the two series were braced together where they passed with blocks 6″ × 4″ × 4″, to which each plank was nailed; these blocks were not placed closer together along a plank than 12″.

(*b*). *Calculations.*—The plate girder was calculated in the usual way. The flange stress at the centre was 11,230 lbs. The stress per square inch of the flanges at the centre was 750 lbs., which allowed sufficient margin for the possibility of buckling in the compression flange or of weakness through nail holes in the tension flange. No attempt was made to reduce the area of the triangular flanges towards the abutments as there would not then have been sufficient nail area for the cover and web planks.

The maximum shearing stress was calculated with a 2-ton wagon at one end of the bridge and the rest of the bridge crowded with cavalry. The web itself is amply safe to carry this. The shearing stress on each nail connecting web planks to flanges at the abutments due to the horizontal shear was 148 lbs., allowing four nails to the horizontal foot-run on each side of the girder. 2½″ cut nails were used here.

The maximum interval at which web planks could be placed (centre to centre) at the middle of the bridge to give sufficient resistance to shearing when half the bridge only was loaded was found to be 2′.

The length of cover plates to allow sufficient nail area, at 12 nails per square foot, to transmit the stress along the flanges was calculated.

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It was found that these flange cover plates had to be nearly continuous in the tension flange and were therefore made entirely so there. In the compression flange the duty of the cover plates is to preserve the alignment of the butting flange pieces and they were made to extend from 18 to 30" each side of each joint to ensure this.

(*c*). *Method of Construction of Girders.*—(*i.*). *Warren.*—This girder was made on a level grass meadow close to the site. It is easy to put together if careful attention is paid to the correct order of planks at each panel point.

It was found that bolts and nuts were much easier and more satisfactory to use than trenails. The former were easy to drive into the holes bored for them and their nuts gave them a good grip on the planks. The latter were hard to drive into position (a red hot poker was found useful for making the holes, but the soundness of this method is perhaps doubtful). When the trenails were driven they got no grip on the planks, which tended to spread apart whenever they received a shock. Nailing the distance pieces between the planks partially remedied this defect.

(*ii.*). *Plate.*—This girder was also put together close to the site. It took less time and was easier to make than the Warren. It was also stiffer than the latter. It was difficult to get a seating for the road transoms on the bottom flanges of this girder ; the web had to be cut through for this purpose, which weakened it.

(*d*). *Method of Launching.*—As soon as the girders were built they were lifted up into vertical planes and placed on stout rollers the right distance apart. They were then braced together with temporary planks nailed diagonally across the top and bottom flanges.

A 6" × 3" plank was then nailed to the bottom flanges at the end nearer the gap, and to it was attached a sling into which was hooked the lower block of a "double and treble" 2" fall. The upper block of the fall was made fast to the cross-piece of a 20' frame on the far bank.

This tackle lifted the outer end of the bridge as it was pushed across and assisted to pull it across. The sling, into which the lower block hooked, passed round both girders to steady them.

To assist in preventing the tipping of the bridge as it moved across the gap, another 6" × 3" plank was secured to the *top* flanges at the inshore end and was held down to holdfasts on each side of the bridge by ropes which were slowly paid out.

Two horizontal guys were also passed round the girders (one round each girder) as lateral preventers.

Fig. 15 (which is not to scale) is a general elevation showing the process of launching. The position of the girder shown by the dotted lines is that when the frame first exerted an *effective lifting* action.

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The main party (on the near bank) push the bridge forward on the rollers. It was found necessary to stop very often because the ends of the sloping braces in the Warren girder got jammed up against the rollers. This is a distinct disadvantage in the open truss type of girder. As there was only one block pulling the bridge across, the latter had a tendency to twist, a result which the constant necessity for lifting the Warren girder tended to increase.

It would have been better to have had *two* blocks and falls from the frame.

The horizontal diagonal braces connecting the bottom flanges of the two girders while they are being pulled across should be of $1\frac{1}{2}$" planking, as they are subjected to considerable crushing stresses when passing over the rollers.

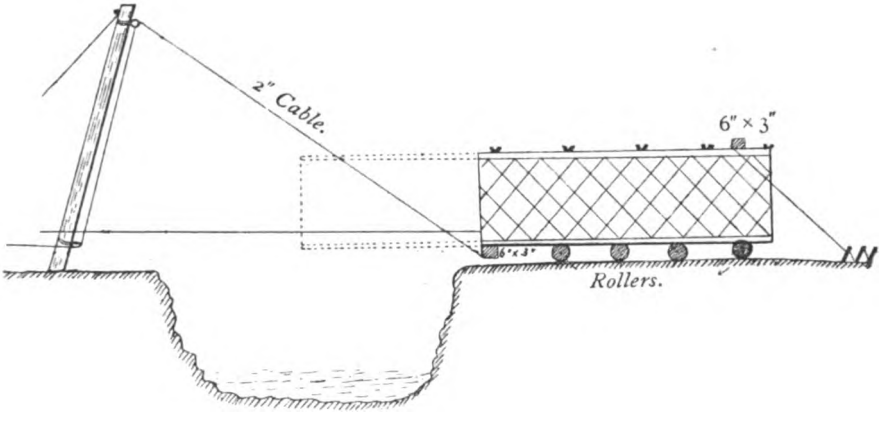

FIG. 15.

(*e*). *Time.*—Six carpenters built and connected the girders in 50 hours. The work being experimental, only a few men worked at it, otherwise it could probably have been built in 20 hours by 16 men. Launching took 50 men one hour.

(*f*). *Remarks.*—The bridge in its final position still retained its camber but might have been stiffened *laterally*.

A few days later, after heavy rain, it was found that in the Warren girder the dowels had swollen and the holes apparently contracted so that the planks had a tendency to tear. This tendency was confined to dowel joints alone. The bolt joints were still good in every way. Lateral oscillation was very small even when a heavy wagon and men moved rapidly across the bridge.

After rain the bridge, which was fixed at one end, expanded in length by $\frac{1}{8}$".

(*g*). *Deflection.*—Careful measurements were taken of the deflection of the girders under various loads.

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The following table gives the results :—

Load at Centre (exclusive of superstructure).	Deflection in Inches at Centre. Plate Girder.	Warren Girder.
50 cwt. (stationary)	$\frac{1}{2}$	$\frac{3}{4}$
„ „ „ *after 5 minutes.*	$\frac{5}{8}$	$\frac{13}{16}$
26 „ „ *after 1½ hours...*	$\frac{5}{8}$	$\frac{13}{16}$
32 „ (moving) when at centre	$\frac{1}{2}$	$\frac{11}{16}$
Permanent deflection at centre after load was removed	$\frac{7}{16}$	$\frac{1}{2}$

N.B.—The maximum deflection permissible may be taken as $\frac{1}{450}$ span ($=1\frac{1}{3}''$).

Joints were examined after the tests; no serious defect was found.

4. 57′ Bridge for Cavalry in Single File.

Built at Christchurch Camp in 1904 by R.E.

Launched by R.E. and Cavalry Pioneers.

Width of roadway 6′, carried on the top of two girders 7′ apart centre to centre.

(*a*). *Description.—Type of Girder.*—Warren. Depth centre to centre of flanges 5′ 6″.

The girders were built up entirely of 8″ telegraph poles for compression members and telegraph wire for tension members with the addition of four planks for counterbracing.

Fig. 16 is a skeleton diagram of a girder. Compression members are shown in continuous lines, tension members in dotted lines.

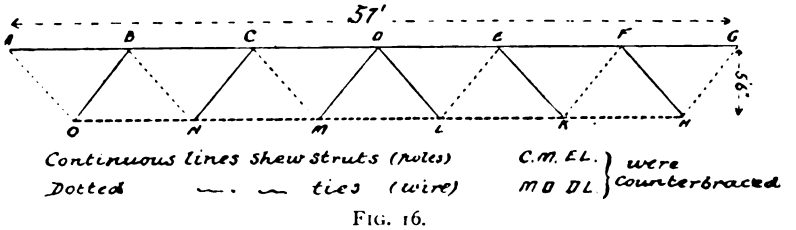

FIG. 16.

The slope of braces was about 49°.

The bridge was intended to be supported on seatings at the bank level on which the ends of the upper flanges should have rested, but owing to the shallowness of the gap a trestle 6′ high had to be erected on each bank upon the transoms of which the ends of the upper flanges of the girders rested.

(*b*). *Method of Construction.*—The chief difficulty lay in the joints, especially those where compression members met.

Description of Joints.—(1). *Top Flange.*—Poles 19′ long, sufficient to cover two panels, were used. The poles of the two top flanges broke joint with each other.

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The girder was put together on its side on the ground. It was given a camber of 1′ at the centre and proportionately at other joints to produce a hog-backed shape. Where two poles met end to end they were cut square and the camber produced by inserting a couple of wedges between them, as in *Fig.* 19. A 2″ oak dowel (AB in *Fig.* 17) was inserted into auger holes bored in each butt.

Joints A and G.—At these joints the wires AO and GH passed through auger holes bored horizontally through the pole.

Joints B, C, E, and F.—At these joints the wires of the diagonal tension braces passed through horizontal holes in the pole nearer the abutment, *e.g.* the wires of BN passed through a hole in AB. The diagonal compression brace was shouldered into the pole farther from the abutment. *Fig.* 18 is a view of the joint at B. *s* is the shoulder cut in the panel BC, against which the brace OB butts. *p* is the auger hole in AB through which the wires of the brace BN pass. *q* and *r* are two other auger holes. OB is wired in its place by series of wires between *r* and *p* and between *r* and *q*.

FIG. 17.

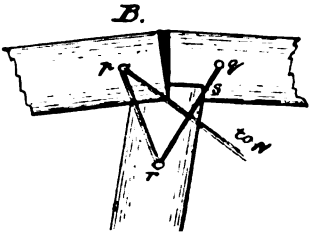

FIG. 18.

Joint D.—This joint has the two braces MD and DL scarfed to butt against each other. They are also slightly recessed into the poles of the top flanges as in *Fig.* 19. The four poles are wired together as shown through auger holes *t*, *v*, *w*, *x*.

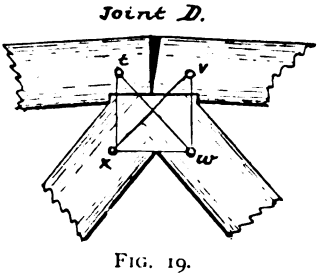

FIG. 19.

Joints O, N, M, L, K, H.—In these joints an auger hole was bored horizontally (at right angles to the plane of the girder) through the pole about 9″ from its end and the wires of the two or three tensional members connected to it were passed through the hole. Wires of each member in the lower flange were independent of those of the next member.

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Horizontal Bracing.—The top flanges were connected together by the usual horizontal lattice bracing of 8″ poles and 2″ boarding. The lower flanges were connected by similar bracing but wire was used for the diagonals, and the poles were 5″ in diameter. Diagonal wires were also placed to cross brace the quadrilaterals formed by each corresponding (*i.e.* opposite and parallel) pair of web braces in the two girders (see *photo*), in order to prevent distortion during launching.

(*c*). *Calculations.*—The Warren girders were calculated in the usual way. The weight of each girder was 2,275 lbs.

The maxima stresses on the web members were as follows :—

AO = GH = − 7,568. OB = HF = + 7,428. BN = FK = − 4,750.

NC = KE = + 4,400. CM = EL = $\begin{cases} -2{,}446 \\ +348. \end{cases}$ MD = DL = $\begin{cases} +1{,}376 \\ \text{or} -402. \end{cases}$

The stresses on compression braces of the web are well within the limits of safety for 8″ spars, provided the joints are well constructed.

Where compression members are liable to reversal of stress (which is only the case in the members MD and DL and then only to a small extent) it is important :—

(*a*). To have no play in the joint.

(*b*). To have the brace wired to the flange at the joint with a sufficient number of returns of wire to take the reverse stress.

The tension members CM and LE were counterbraced by nailing a couple of planks on either side of the tie and bracing them together. These planks are not seen in the photograph as they were not put on until the girder had taken up its final position and the wires were fully stretched.

The maxima stresses in the lower members were as follows :—

ON = KH = − 9,616 lbs.

NM = LK = − 15,504 lbs.

ML = − 17,377 lbs.

The upper flange members, being in compression, are obviously sufficiently strong.

The number of wires in tension members was proportioned to the stresses in them.

(*d*). *Testing a Girder.*—One girder was tested in the following way (*Fig.* 20) :—Two pairs of sheers, *a* and *d*, 10′ to the crutch were placed about 57′ apart and well stayed. The girder was erected in a vertical plane and then lifted on to the two sheers so that it was clear of the ground and supported by the ends of the top flange only. In this position it was found to have lost its camber, which was restored to it by the following method.

Two more pairs of sheers, *b* and *c*, 11′ to the crutch were made. The girder was then lifted off the crutches of the sheers *a* and *d* by about 25 men and the new sheers were placed a little way each side of the

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centre as at *b* and *c*. The sheers *a* and *d* then took none of the weight and the ends of the upper flange sagged, the joints opened a little more, thicker wedges were driven in, and the wires of all tension members were tightly windlassed. The sheers *b* and *c* were then gradually lowered and the girder once more rested on *a* and *d*; and this time it retained its camber owing to the increased thickness of the wedges and the shortening of the ties.

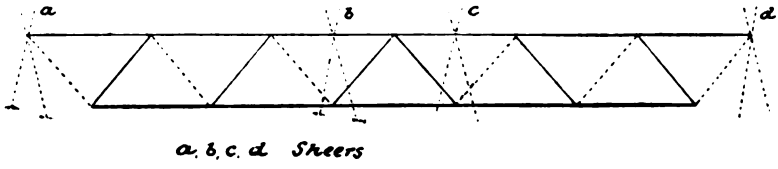

FIG. 20.

The testing was then carried out by erecting a derrick F about 15′ high (10′ would suffice) opposite to and 13′ 6″ away from the centre of the girder (see *Figs.* 21 and 22). A single block G was lashed to its tip. Two stout pickets DD were then driven into the ground 1′ 6″ from the centre of the girder and a cross-piece C lashed to them about 3′ above the ground. A strong lever E was placed under C and one end, which was vertically under the centre of the top flange of the girder A, was connected to it by 36 wires, while the other end, which was vertically under the block G, was secured to a fall which passed through G and held a tray at H which could be

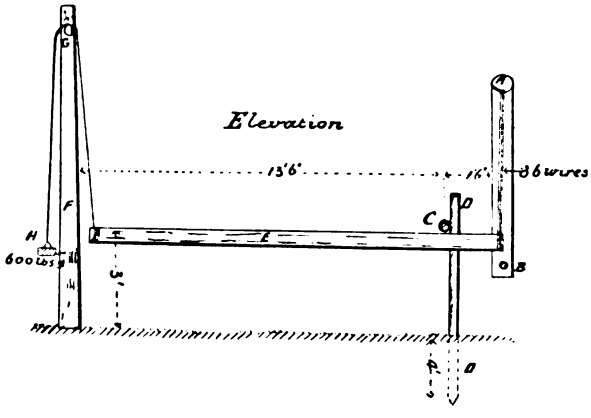

FIG. 21.

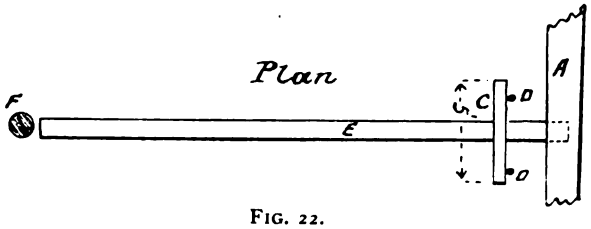

FIG. 22.

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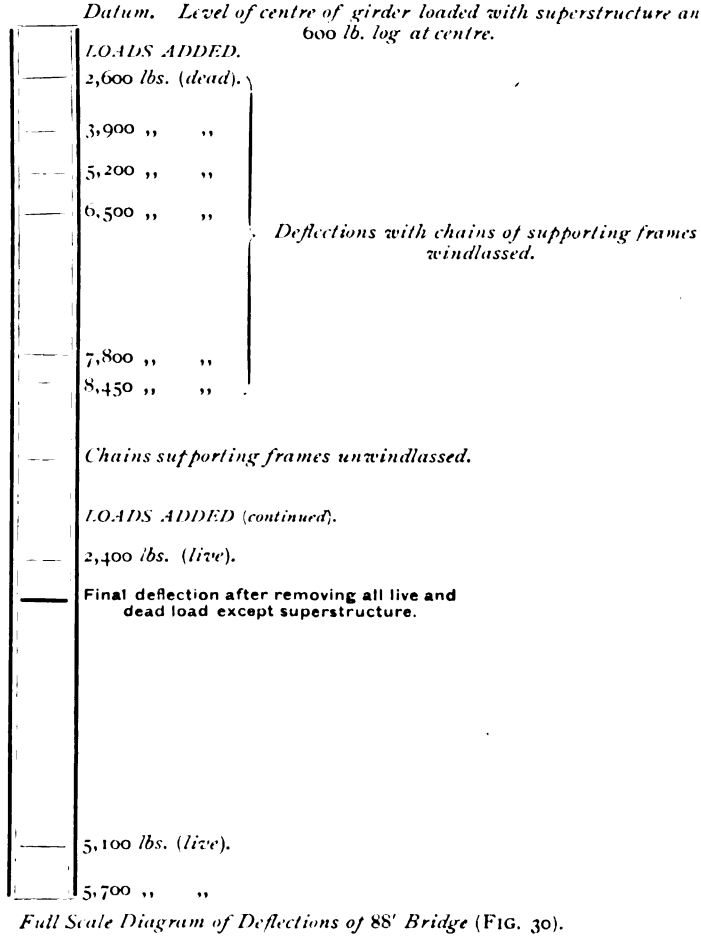
loaded with sandbags of known weight. The arms of the lever E pivoting at C were as 9 to 1.

Weight was added to H till, when 600 lbs. was on the tray and the deflection at the centre was 4", one of the tension members in the bottom flange, B, tore through its auger hole. The equivalent load on the centre of the girder when this occurred was of course 5,400 lbs. The top joints had stood the test well, with no signs of failure.

The actual failure could easily be remedied by binding round the poles with wire at the auger holes. This was subsequently done everywhere. No further test was made as the girder had otherwise stood the required test. (A central load of 5,400 lbs. on one girder equals a distributed load of 21,600 lbs. or 380 lbs. per foot-run on the bridge).


Datum.
Level of centre of girder loaded with superstructure and 600 lb. log at centre.
LOADS ADDED.
2,600 lbs. (dead).
3,900 ,, ,,
5,200 ,, ,,
6,500 ,, ,,
Deflections with chains of supporting frames windlassed.
7,800 ,, ,,
8,450 ,, ,,
Chains supporting frames unwindlassed.
LOADS ADDED (continued).
2,400 lbs. (live).
Final deflection after removing all live and dead load except superstructure.
5,100 lbs. (live).
5,700 ,, ,,

Full Scale Diagram of Deflections of 88' Bridge (FIG. 30).

FIG. 23.

(*e*). *Launching the Girders.*—The girders were carried one by one by a party of about 40 men to the edge of the gap and were then

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erected vertically, parallel to each other and the proper distance apart. They were propped up in this position while the horizontal diagonal bracing between the top flanges and the wire bracing between the bottom flanges and web was fixed. Two 20′ two-legged frames were meanwhile erected either side of the gap with the legs far enough apart for the whole bridge to pass between them. A block and tackle was suspended from each frame transom and hooked on to bridles fastened to the top flanges. By means of these tackle the whole bridge was lifted by the near side frame and pulled by the far side frame across the gap. The bridles had to be occasionally shifted and while this was being done the weight of the girders was taken by extra ropes passing through single blocks lashed to the tops of the frames.

Lateral preventer ropes were very necessary (fixed to the top flanges) while the bridge was moving across, as there was some tendency for the camber to translate itself into a lateral deviation of the top flange.

The process of launching was not very satisfactory owing to the fact that the gap was a shallow muddy one instead of a deep one (for which girder bridges are best suited). When the forward end sagged as it moved across it rested on the mud. Had the gap been deep enough it would have been practicable to allow the forward end to droop very considerably, as it could be pulled up again by a nearly vertical hoist when it got across.

When the bridge was across, trestles were erected to carry the ends of the top flanges.

(*f*). *Time Table of making One Girder :—*

	Men-Hours Labour.
Cutting poles to length	9
Making dowels	2
„ joints on top flange	21
Boring auger holes (and wiring round ends of poles)	10
Wiring tension members	66
Total labour for one girder ...	108
„ „ „ two girders ...	216
Carrying to gap and raising (30 men 1 hour)	30
	246
Cross bracing between girders (12 men 8 hours)	96
Launching bridge (50 men 3 hours) ...	150
Total labour	492

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A suitable distribution would be as follows :—

Building two girders	36 men 6 hours.
Carrying to gap and raising	36 men 1 hour.
Erecting frames and cross-bracing between girder	36 men 3 hours.
Launching	36 men 3 hours.
Total labour	36 men 13 hours.

(*g*). *Remarks on the Completed Bridge.*—After a short time the girders lost their camber. It would have been advisable to give 1′ 6″ to 2′ camber at the centre in constructing them.

The bridge was very stiff and had little lateral oscillation. It would be a good thing to give it a greater depth, but this is difficult as girders deeper than 6′ or 7′ are very difficult to erect and launch. Wooden gusset plates or fish plates at all the top flange joints would relieve the strain on the dowels which may fail without giving warning, though no instance of this occurred.

As the top flange joints stood the test load admirably they would probably be found satisfactory under service conditions. This kind of bridge might be of use when time was not of the highest importance, or when no other material to span a deep gap or a torrent was at hand. No material other than poles and wire is needed, no tools besides augers, saws and pliers, and very little skilled labour.

5. 78′ Bridge for Cavalry in Single File.

Built at R.M.C., Kingston, Canada, in 1906 by cadets.

(*a*). *Description.*—Width of roadway 6′. Carried on top of one girder of triangular cross section. Depth of girder centre to centre 6′.

Type of Girder.—It was thought that a girder bridge of cross section as in *Fig.* 24, *i.e.* having two top flanges and one bottom flange, would provide greater freedom from internal distortion and would save material and weight. It was in fact two girders inclined to the vertical and having a common lower flange. Results proved that the type though strong enough when finally in position was not satisfactory, as it had to be launched upside down and then turned over, a process which took much time just when time should especially be economized. It was found as well that a loss in the lateral stiffness of the lower flange resulted, which allowed overmuch oscillation.

Considering the bridge as composed of two girders, having a common lower flange, the top flanges consisted of 8″ round spruce spars, in 10′ and 20′ lengths and the bottom flange of 10″ spars in two 27′ lengths and one 14′ length, butting where they met. The butt joints of all flanges were strengthened by $1\frac{1}{8}$″ oak trenails 16″ long placed in axial holes in the end of each pole $8\frac{1}{4}$″ deep and 2″ diameter : in

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the case of the top flanges the joints were further secured by three planks, $4'' \times 2''$, $4'$ long, fishing the joint on the top and the two sides. Each butt joint of the bottom flange was connected up by a wire sling of the necessary strength to take the tensional stress, passing through transverse $2''$ auger holes $2'$ from the ends of the spars. It will be seen in *Fig.* 29 (where the girder is upside down) that the lower flange was only $68'$ long, which was sufficient.

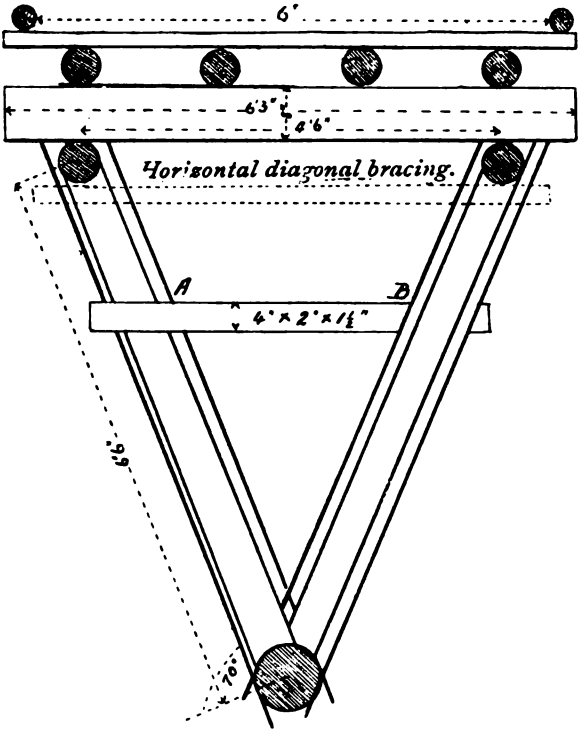

FIG. 24.

The web consisted of $8''$ by $1\frac{1}{2}''$ boarding nailed diagonally on the outside to top and bottom flanges; the boards touched each other at the abutments and were spaced at $2'$ central interval at the centre: and on the inside of each girder there was another series of diagonal boarding, $8'' \times 2''$, running the contrary way and spaced at equal central intervals of about $5'$ throughout.

Distance Pieces between Top and Bottom Flanges.— Every $5'$ along each girder a distance piece or stiffener $6'\ 6'' \times 8' \times 2''$, was placed perpendicular to the flanges and shaped at the ends to fit them as in *Fig.* 25.

FIG. 25.

The four distance pieces at the ends were $3''$ thick.

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The distance pieces on each girder were placed not quite opposite to each other (or they would have interfered with each other on the common lower flange), but close enough to allow a horizontal brace (AB in *Fig.* 24) to be nailed across them.

The upper sides of the joints of the top flanges were wedged with pieces of $\frac{1}{8}''$ sheet iron to give a camber to the bridge.

Wind Bracing.—8″ road transoms were spiked across the two top flanges at 8′ 6″ central interval and between them a system of horizontal lattice bracing of 8″ × $1\frac{1}{2}''$ planks was spiked to the underside of the flanges. The top flanges were also wired together at intervals to prevent them spreading.

Duplication of Web at Abutments.—The diagonal web boarding near the abutments was strengthened by cross boarding of the same size. This cross boarding covered the whole face of the girder for 15′ from each abutment. The cross boarding was not completed till after launching.

(*b*). *Method of Construction.*—The three flanges were first of all built up upon a platform of small piles of chesses at intervals, the tops of which were levelled. A pile was placed under each joint in a flange.

The ends of spars in the flanges were cut square and bored for the dowels, which were inserted. The sheet-iron wedges on the upper side of the top flanges were inserted and the fish plates nailed on. The joints of lower flange were wired together.

The two top flanges were placed parallel and at the correct distance apart and framed together by means of the transoms and wind bracing which were spiked on.

This frame (78′ × 4′ 6″) was then raised to the required angle and propped (as XY in *Fig.* 26). The bottom flange Z was placed in the correct position with reference to XY. The stiffeners XZ and YZ were then fixed and connected by the transverse pieces AB (*Fig.* 24) and then the exterior and interior web boards were nailed on.

The girder had to be revolved about the lower flange in to the position $X_1Y_1Z_1$ (*Fig.* 27) to complete the boarding.

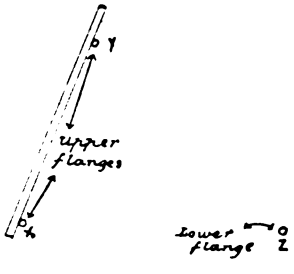

FIG. 26.

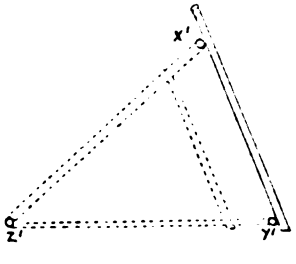

FIG. 27.

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Only every other board in the web was nailed on before launching in order to lighten the weight. The remainder were nailed on when the girder was in site.

The exterior and interior boarding in one girder ran the reverse way to each other diagonally. The two systems of exterior boarding also ran the reverse way to each other.

All web boards were nailed to the stiffeners where they passed them.

On the completion of the girder it was turned over on to XY (*i.e.* upside down) ready for launching.

(*c*). *Calculations.*—The bridge was calculated as though it consisted of two ordinary plate girders, each with a lower flange equal to half the 10″ spar forming the single lower flange of the bridge. The weight of the total bridge (exclusive of road-bearers and chesses) was about 8,000 lbs., of which the flanges weighed 3,377 lbs.

It was found that the horizontal shearing stress at the abutments was 3,333 lbs. per foot-run (both girders together).

It was necessary to ascertain the ultimate resistance of the nails employed (6″ wire) connecting the timbers employed (1½″ fir planks to spruce logs).

This was found by experiment to be about 800 lbs. per nail.*

Four 6″ wire nails can easily be driven side by side as at *aaaa* without hurting the fibres of the board, and if necessary three more nails might be driven as at *bbb* (*Fig.* 28).

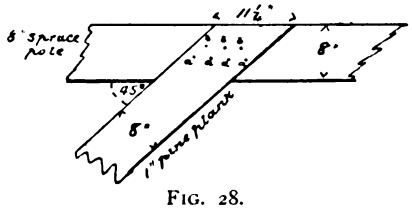

FIG. 28.

Now each web plank was 8″ wide and being placed at 45° to the flange took up a length of 11″ along the flange. There were two sets of

* *Experiments.*

Thickness of Plank.	Kind of Nail.	Breaking Stress (per nail).	Nature of Break.	Remarks.
2″	6″ wire.	809	Nails pulled out of log.	Nails driven home.
1″	6″ wire.	785	Nails pulled through boards.	Ditto.
1″	6″ wire.	693	Ditto	Heads not driven into board.
1″	6″ cut.	537	1 nail broke ..... 1 ,, pulled through board.....	Heads not driven into board.
1″	6″ cut.	720	Ditto	Nails driven home.

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web planks. Allowing a factor of safety of three, the required number of nails connecting each plank to each flange was $\frac{3333 \times 11 \times 3}{12 \times 2 \times 800} = 6$, which could be driven without splitting the planks.

It must also be remembered that the web was also strengthened by double boarding at the abutments.

The spars of which the flanges were composed, were strong enough against compressive and tensional stresses and the number of wires connecting the spars in the lower flange was calculated in the usual way.

(*d*). *Method of Launching Girder* (*Fig.* 29).—The girder was launched by means of (*a*) a 58′ derrick, F, in the centre line of the bridge on the far side of the gap.

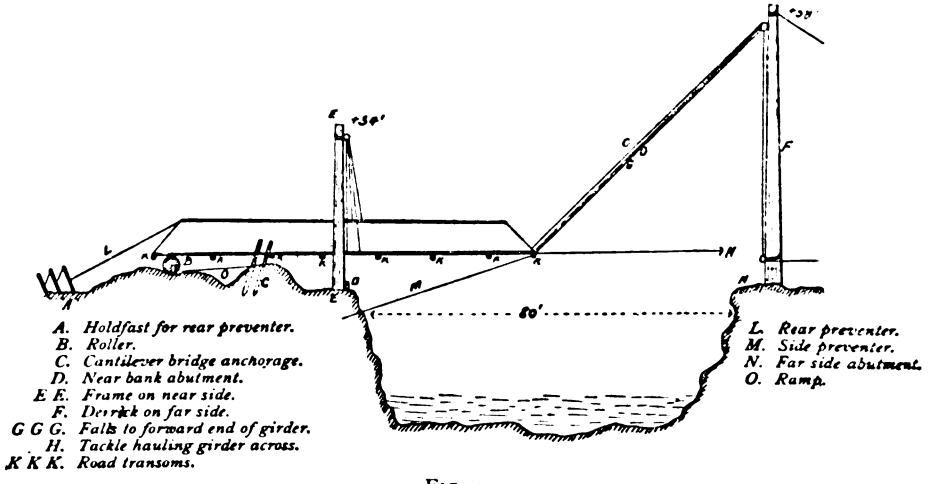
A. Holdfast for rear preventer.
B. Roller.
C. Cantilever bridge anchorage.
D. Near bank abutment.
E E. Frame on near side.
F. Derrick on far side.
G G G. Falls to forward end of girder.
H. Tackle hauling girder across.
K K K. Road transoms.
L. Rear preventer.
M. Side preventer.
N. Far side abutment.
O. Ramp.
80′

FIG. 29.

(*b*). A 35′ 2-legged frame, E, astride the centre line of the bridge on the near side of the gap, between the legs of which the bridge passed as it was launched.

The derrick had, lashed to its tip, three single blocks, through which falls passed to the girder. These falls were connected to "runner" tackles.

The frame had, lashed to its transom, four single blocks. Through these blocks falls passed, two of which were connected to runner tackles and two to holdfasts (the latter assisted to take the weight and were paid out as the girder went forward).

The bridge was launched upside down as it was of triangular section and would have been difficult to keep upright, had it been launched on its lower flange. Four elm rollers, B, each 3′ long and 20″ diameter, stripped of their bark, were used to roll it forward.

The mistake had been made of lashing on the road transoms KK across the top flanges during construction. When the girder was

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turned upside down these transoms impeded the rolling action, as every time the girder advanced 10′ (*i.e.* one bay of roadway) the roller got foul of the transom and the girder had to be lifted to get out each roller in turn to roll it forward; cross planks should have been nailed *above* the two flanges and the transoms not put on till later.

Another serious impediment to launching was an old cantilever bridge anchorage, C, which it was not thought desirable to remove, and which was in the direct line just behind the near abutment. The road transoms, as they came in turn to this anchorage, had each to be lifted over it, causing great waste of time and moreover, as the ground just in rear of the anchorage was rather low, the weight of the girder was frequently taken by the anchorage logs instead of by the roller, causing a great increase of friction.

A plank platform, O, was placed behind the abutment and was used to roll the rollers up.

The rolling forward proceeded easily except for the above impediments. The tackles were not needed until the girder got more than 40′ (half its length) beyond the cantilever bridge anchorage, which formed the practical abutment, as the real abutment at D (*Fig.* 29) was too far below the natural forward line of movement of the girder to take its weight till the end.

As soon as the girder got more than half-way out the tackles were brought into use. The three from the derrick (G,G,G) on the far side were made fast to the forward transom, which was of course below (this transom was connected also to the two transoms in rear of it to distribute the stress and avoid pulling the forward transom off).

The four tackles from the frame on the near side were made fast, two to the lower flange (*i.e.* that on top), and one to each upper flange (*i.e.* those at the bottom). They were at first made fast vertically, but as the girder went forward they of course became inclined, and exercised a retarding influence on the girder. It was therefore necessary frequently to cast them off in turn and take them back to a point further back on the girder. A horizontal treble and double tackle was made fast to a holdfast on the opposite shore and to the forward transom of the girder to give a direct pull across. The falls from the top of the derrick gave too vertical a pull owing to the great height of the derrick, and the stress on them would have been too great had they been used as the only forward-pulling agency.

There is always a chance of the girder during launching rushing forward or "taking charge." To avoid this the following preventer ropes are necessary :—Two from the rear to the rear of the girder (L), and one from each side to the front of the girder (M). The former (which prevent the girder rushing forward) may be made fast to the

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upper side of the girder when the bridge is more than half-way out at which time also the latter may be transferred to holdfasts on the opposite bank.

It would probably have been better to have had runner tackle to all four falls on the near side. Grease should be applied liberally, both to all sheaves and to all parts where the girder or rollers move.

Handspikes (not only 6′ ones but two or three 12′ ones of hard wood) are essential for actual lifting and to encourage the girder forward over bad places. Plenty of packing is also necessary to take the weight at times.

It is important, when the girder is close to the far side, to keep the flanges which are to rest on the abutment N well up above it. Otherwise there is a very considerable lift necessary with the tackle, which may cause difficulty.

Turning the Girder.—As the girder was launched upside down it was necessary to reverse it after it had reached the far side. For this purpose the tackles were arranged as follows :—Five were fixed at equidistant points along that top flange which it was proposed to lift (that flange being of course at the bottom and sustaining half the weight); and two to the bottom flange (*i.e.* that flange at the time on top) to lower away gently and prevent the revolution being too sudden. It was found to be easy to turn the girder, but when it was *half* round it had to support its own weight over the span, although on its side and with its flanges and web quite wrongly placed to resist such a stress. The result was that it bent a great deal when in that position, and some of the joints got somewhat racked. The conclusion arrived at was that this method of launching the girder upside down and then turning it is not sound, owing to the unfair stresses to which the joints are liable during the process.

It is always advisable to allow plenty of length in the girder to give a good seating on the abutments and so to avoid the possibility of it being dragged off either abutment. This actually happened and greatly retarded the work.

It would have been wise to have built the near side frame without diagonals and with side struts and guys instead. This would have allowed the tackle from that frame to swing freely backward and forward without interfering with the diagonals.

(*e*). *Time.*—Men-hours labour employed :—

	M.H.
A. Construction of girder	296
B. Launching. (Excessive, for reasons given above)...	313
C. Turning. („ „ „ „ „)...	120
D. Fixing remaining bracing	43
E. Roadway	51
Total	823

N.B.—In addition to above the derrick took 147 M.H. and the frame 50 M.H. Making a total of 1,020 M.H.

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(*f*). *Test.*—A class of 28 cadets started half from each end of the bridge and marched towards each other, meeting crowded at the centre and marking time. The deflection increased temporarily to $3\frac{1}{2}''$ and permanently to 2″.

Load=4,200 lbs. live central=8,400 live distributed=108 lbs. live load per foot-run, to which must be added the weight of the girder (8,000 lbs.) and of the roadway (6,000 lbs.)=A total *dead* distributed load of 26,600 lbs., *i.e.* 340 lbs. per foot-run.

This triangular cross section of the plate girder bridge however is not recommended. It was purely experimental, and the necessity of launching it upside down and then turning it over forbids its use where time in launching is to be reduced to a minimum.

6. 88′ Bridge for Cavalry in Single File.

Built at R.M.C., Kingston, Canada, in 1908 by cadets. Width of roadway 6′, carried on top of two girders 7′ 4″ centre to centre.

(*a*). *Description.—Type of Girder.*—Each girder was of the "double Warren" or lattice type (*Fig.* 30), the braces of the web making an angle of 45° with the flanges. Depth (centre to centre of flanges) 7′ 4″.

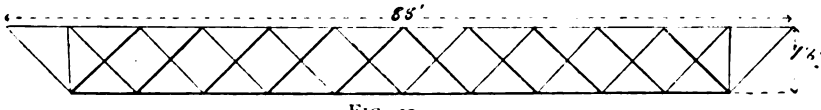

Fig. 30.

The flanges consisted of 5″ × 5″ scantlings, 10′ and 20′ long. The pieces butted and were connected at the joints by two fish-plate pieces (above and below the joint) 5″ × $2\frac{1}{2}$″ or 2″. In the compression flanges the butting surfaces were considered to be partly capable of taking up the compressive stress and the "fish plates" extended 4 or 5′ each side of the joint and were nailed to the flange. In the tension flanges the stress was transferred across each joint by bolting the pair of "fish plates" together through the flange on both sides of the joint in the usual way, a sufficient number of $\frac{1}{2}$″ bolts and nuts (from 5 to 8) being used each side of the joint and the "fish-plates" were made long enough to take them all, at 6″ central intervals.

No reduction of the size of the flanges was made towards the abutments, as they would in that case not have been large enough to take the bolts.

Each web brace consisted of a pair of planks of the necessary scantling (varying from 5″ × 3″ at the abutments to 3″ × 1″ at the centre). The web planks were bolted through the flanges at each end with a bolt of sufficient diameter (varying from 1″ to $\frac{3}{8}$″) and were nailed to the planks of the opposite braces where they crossed each other at the middle.

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Each pair of compression braces, or tension braces liable to counter stress, was connected with small lattice bracing nailed on at 45° to the direction of the brace. Each pair of tension braces was connected above and below its centre with a pair of small lattice braces.

Wind Bracing.—(*a*). *Lower Flanges.*—Horizontal diagonal planks were nailed across the tops of the flanges.

(*b*). *Upper Flanges.*—The road transoms 6″ × 6″ were notched 1″ deep on the underside and placed across the flanges (which fitted into the notches) and were then spiked to the flanges. A lattice system of horizontal diagonal planking was fixed in pairs between the transoms, both planks being on the top of the upper flanges. Planks were 6″ × 1″.

Abutment Pieces.—The ends of the top flanges rested on the abutments and since they carried the whole weight they were reinforced by pieces 4′ × 8″ × 5″ wired underneath them. These pieces should have been bolted to the ends of the flanges.

Transverse Diagonal Bracing.—It was thought advisable to cross brace the bridge at intervals, *i.e.* by fixing bracing from the top flange of one girder to the bottom flange of the other girder and *vice versâ*, to prevent distortion during launching.

This diagonal bracing between the girders was fixed as follows (*Fig.* 31) :—

Two 6″ × 1½″ planks were nailed, the first from A on a web brace of one girder to B on the web brace of the other and the second from C on a web brace of the latter girder to D on a web brace of the former. So that a web brace of one girder is cross braced to the web brace opposite to it on the other girder. Every alternate pair of web braces sloping one way and every alternate pair sloping the other way were thus cross braced together.

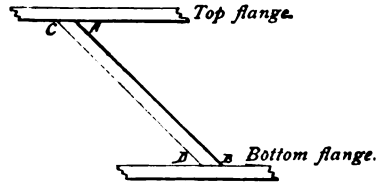

FIG. 31.

(*b*). *Calculations.*—The girders were calculated in the usual way to arrive at the necessary dimensions of planks and sizes of bolts for bearing and shearing. The cross section of the flanges was for convenience kept the same throughout.

(*c*). *Method of Construction and Erection of Girders.*—The flanges were put together on a low staging of piles of chesses and bolted or nailed up with the cover plates.

The top and bottom flanges of a girder were then laid on their sides

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at the correct interval, a camber was given them by picketing the ends and intermediate points and the web braces on one side laid on. The holes in the flanges and in the web braces for the bolts were then marked and bored and the bolts driven through.

The girder was then turned over and the web braces on the other side bored and threaded on the bolts which were then nutted up. It is necessary to thread the web braces at important joints, *i.e.* those towards the abutment, so that a minimum shearing stress comes on the bolts (see page 198).

The two girders having been thus bolted up were raised into vertical planes, opposite each other and the correct distance apart. This operation was easily done by 30 men.

Each girder was strutted up with planks and then temporarily secured as in *Fig.* 32, where AB and CD are the two girders, AC is light planking nailed between the top flanges, AE and CF are guys.

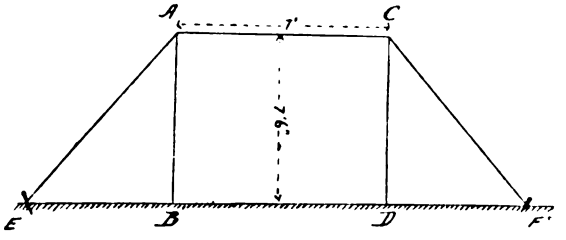

FIG. 32.

It is important to get the lower flanges parallel and correctly placed, the right distance apart and opposite each other. The top flanges can be placed in the right vertical planes subsequently.

As soon as the bottom flanges are correctly placed the lower flange wind bracing should be fixed to keep them correct. The top flanges must then be pulled to the right distance apart throughout and the planks AC renailed to keep them there. The transoms having been prepared with notches 1" deep to fit over the flanges are placed and nailed down. The upper ends of *compression* braces (beyond the bolt) may be sawn off, but not closer to a bolt hole than 4".

Next, the top flange wind bracing may be fixed. In the meantime the lower flanges must be blocked up level and plumb bobs hung from the top flanges to see that they are vertically over the bottom flanges throughout.

Then the transverse diagonal bracing between the girders is fixed and the bridge is ready to carry forward and launch.

Notes on Construction Details.—All holes for bolts were bored with an auger $\frac{1}{8}$ less than diameter of bolt.

Where braces passed each other, a 5" distance piece was placed between them to which they were nailed.

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The heads of bolts through lower flange cover plates were downwards so that the nutted end would not interfere with rolling out.

(*d*). *Test of* 88′ *Bridge.—Fig.* 23 is a graphical representation of carefully measured deflections taken at the centre under *central* loads of amounts shown. The deflections given are those of the better built of the two girders; the other girder had a weak spot and consequently gave deflections 20 to 30 per cent. greater than those shown.

It will be seen that the deflection under a load equal in value to cavalry in single file was $\frac{1}{300}$ the span: further, that the chains of the strengthening frames gave some assistance, as their release increased the deflection by the amount shown; and lastly that the bridge had by no means reached its elastic limit, even when loaded with a weight equal to 25 per cent. more than cavalry in single file, as is seen by the reduced deflection when the excessive load was removed.

(*To be continued*).

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THE COMPLETION OF THE BARO-KANO RAILWAY.

By Capt. F. D. Hammond, R.E.

In his lecture on the construction of the Baro-Kano Railway given at the S.M.E. in October last and subsequently printed in the April number of the *R.E. Journal*, Capt. Mance was only able to deal with that portion of the work which had been done prior to June, 1910. A brief account therefore of the last year's work up to the time when railhead reached Kano, together with a few notes on organisation, locomotive work, etc., may be of interest.

It will save reference to the article in question to give a *résumé* of the main features and direction of the railway. Baro is situated 400 miles up the left bank of the Niger; ocean-going steamers drawing about 11′ of water with a carrying capacity of roughly 1,000 tons, known locally as branch-boats, can reach Baro during high river which lasts from the beginning of August till the middle of October; during the remainder of the year the freight is carried by stern wheeler tugs and barges. The railway follows roughly a north-easterly direction on the first section from Baro to Minna, with gradients of 1 in 143 in the upward, and 1 in 166 in the downward direction. Minna (mile 111) is the first engine-changing station, and the point chosen for the junction with the Lagos Government Railway. On the next section from Minna to Kaduna (mile 215½), where the line crosses the river of that name, the gradient is changed to 1 in 60 in both directions owing to the more broken nature of the country. From Kaduna to Zaria (mile 266), the junction of the new line to the Bauchi tin fields, the gradient remains the same, but from that point to Kano (mile 355½) is decreased to 1 in 80.

The rail used is of British standard section weighing 45 lbs. to the yard and 30′ long, with steel sleepers, 72 lbs. in weight, with 12 sleepers to the rail length.

By June, 1910, track had been laid as far as mile 212 by means of deviations, but as the permanent bridges had only been completed as far as Kugo (mile 176), it was decided to run through traffic only up to that point during the rainy season which lasts from the middle of May to the middle of October.

Transport of Material.

As a general rule in any new railway, such as the one under notice, which taps an entirely new and hitherto unexploited country, the

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carriage of materials for construction, provided the latter is carried on at anything like a reasonable speed, will be greatly in excess of any public traffic which may be expected for the first few years after construction is completed. There are of course a few notable exceptions where areas are opened up which are very rich in natural products and which require practically no development to return a large and paying traffic, but these may be regarded as special cases. In the ordinary circumstances it is therefore essential to economy, that such an expensive item as the rolling stock should be cut down to the absolute minimum necessary for constructing the line according to the programme and rate of speed laid down.

In this particular case the rolling stock decided upon as the necessary minimum, consisted of eight 8-coupled and five 6-coupled main line, and five shunting engines, 190 low-sided and 25 high-sided bogie trucks, of which one 8-coupled and one 6-coupled engine and all the high-sided trucks arrived at Baro in October, 1910, and were available for the final year's programme only.

This quantity of rolling stock would have been inadequate to transport the large supplies of material required at railhead whilst platelaying was in actual progress, in addition to complying with the various demands of mail, ballast, pick-up trains, etc., and therefore the opportunity was taken during the rainy season to forward all material as far up the line as possible. Two depôts were formed to receive it, one at Kugo and one at Minna, to which all permanent way and bridge material either on hand at Baro or arriving there during the shipping season was despatched; in the latter case rails and sleepers were loaded direct from the steamers into trucks.

Much extra handling would have been saved if everything could have been sent direct to the depôt at Kugo and off-loaded there, but this was impossible both because the change of gradient from 1 in 143 to 1 in 60 north of Minna cut down by about 50 per cent. the loads which any particular class of engine could pull, and also because the banks on this northern section were new and it was not considered safe to work the heavier 8-coupled engines over them during the first rainy season after they had been made, so that, whereas the trains on the Baro-Minna section consisted of 20 loaded bogies, north of Minna 7 bogies were the maximum load during these months. To get the greatest work possible out of the trucks, all those arriving at Minna which could not be forwarded to Kugo within 24 hours were off-loaded and the empty trucks returned to Baro. By this means all heavy material was cleared out of Baro by the end of October.

The completion of the permanent bridges north of Kugo was meanwhile pushed on, but work was considerably delayed by late and exceptionally heavy rains. The bridges were finished and the four miles of track which still remained to be laid to reach Kaduna were

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completed by the first week in November. A depôt was at once started there, to which the material stacked at Minna and Kugo was forwarded. By this time the rains had stopped and the track and banks on this section were in sufficiently good condition to permit the working of the heavier engines. This facilitated the work by increasing the train loads which could be taken. The depôt at Minna was cleared by the middle of December and that at Kugo by the end of January. The latter portion of this was done after platelaying had commenced but the lead was not great so that but few engines were required up to that time on the railhead section.

The next item which required attention was the picking up of material on the lower section, which was very important as it was required for subsequent use in laying the main line; several miles of rails alone had to be picked up, the majority being from old deviations and a very large number were bent and required straightening before they could be used again. All was forwarded to Kaduna where it was sorted out and the bent rails straightened by three rail-straightening machines worked by hand power. The maximum output of these machines was 40 rails a day per machine, working with double shifts of labourers.

The one disadvantage in this scheme of transporting material by successive stages was the expense involved in loading and unloading, but this was insignificant when compared with what would have been the cost of the extra locomotives and trucks necessary to take it direct from the base to railhead whilst platelaying was in actual progress, and with the lead increasing by over a mile a day. To this undoubtedly the subsequent success of the platelaying programme was due in a large measure, as on no occasion was railhead ever held up for want of material.

Platelaying.

It is unnecessary to describe in detail the methods employed in platelaying as these were dealt with fully in the previous article. As before, Lieut. Maxwell, R.E., was in charge of this section of the work.

In the programme for the season as originally laid down, it had been arranged to start tracklaying early in November, but, as mentioned above, the late rains had delayed the erection of the permanent bridges and consequently the construction of the deviation across the Kaduna River. The latter was finished on the 11th December and platelaying commenced on the following day. This delay was not in a way disadvantageous as it not only allowed of more material being brought up to Kaduna but also permitted the party in front, engaged in putting in deviations and minor culverts, to get a substantial lead of about 15 miles, and so avoid the trouble of previous years when railhead was frequently held up owing to culverts, etc., not being ready. This lead they were able to keep until Kano was reached.

Owing to the late start, and to obviate any chance of interruption

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by an early rainy season, tracklaying had to be pushed on at the fastest rate which circumstances would allow. The ruling factor in this was the rate of supply of material, as the platelaying party were quite competent to lay down as much as could be sent up from the depôts.

The average amount laid each working day varied from 1½ to 2 miles a day; this, allowing for Sundays, public holidays, changing camp, etc., averaged out about 38 miles a month. This average was maintained for the first 115 miles which were laid in 90 days, including all non-working days. By this date, the 11th of March, such good progress had been made that only 24 miles remained to be laid in order to reach Kano, and any fear of interruption by early rain was needless and the rate of progress was consequently eased off slightly. Kano (mile 355½) was reached on April 1st, the whole distance of 139½ miles having been laid in 111 days, an average of 1·26 miles per day.

The number of labourers employed in the platelaying, keying and first lift parties varied from 990 in December up to 1,270 in March.

The table below shows the actual progress made each month; the 3⅕ miles shown as being laid south of Kaduna in October and November were not laid by the proper platelaying party but by a small gang, and did not form part of the season's platelaying programme. They are therefore not included in the statistics given above.

1910—1911. Month.	Main Line. Mileage.	Additional Track laid.	Cutting out Deviations.
October	$1\frac{7}{10}$	—	—
November	$1\frac{1}{2}$	2	—
December	22	1	—
January	$36\frac{3}{5}$	2	—
February	37	$1\frac{1}{4}$	—
March	$42\frac{1}{2}$	1	1
April	$1\frac{3}{4}$	$\frac{1}{2}$	1
	$143\frac{1}{20}$	$7\frac{3}{4}$	2

WORLD'S RECORD IN TELESCOPIC TRACKLAYING.

It had been arranged that an attempt should be made to beat the world's record of 5 miles for a single day's telescopic platelaying made by Messrs. Pauling in Rhodesia. This was successfully accomplished on March 8th when 6⅓ miles were laid. Work was commenced at 5.50 a.m. and finished at 6.40 p.m. A further ¼ mile had been laid out, but it was not possible to link it up owing to the darkness coming on and all the gangs being tired out. 1,622 natives were employed and 17 Europeans, of the latter all but four were either Sappers or ex-Sappers. Three large and one small engine were employed, the last being used solely on taking tank trucks back to be filled and returning with them to the large engines. About ½ mile of sidings was laid on the previous day for the

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accommodation of material trucks. It is interesting to note that the weight of rails and sleepers handled, alone amounted to over 900 tons. Usually when an attempt of this kind is made the average of work done suffers owing to the time taken in preparations, but this did not occur in this case as the track laid during that particular week was 10¼ miles, which was well up to the average.

Water Supply.

One of the worst difficulties with which the officer in charge of the platelaying party had to contend was the supply of watering facilities to the engines on the upper section. Throughout the more northerly portion of the Protectorate water is comparatively scarce and is usually obtained from wells. In a few places temporary earth dams had been made, towards the end of the rainy season, across the beds of streams, but in most cases water had to be found by digging in the dried-up beds, and as these holes soon became exhausted new ones had continually to be made to replace them. Improvised tank trucks were found to be of great use under these conditions; they consisted of four 400-gallon tanks connected together and erected on a low-sided bogie with a hand pump for pumping into the tender. Three such trucks were used, one on the construction train, one with the engine feeding the construction train with material, and the third wherever required most.

Organization.

The ordinary procedure in railway construction is to divide up the line into various sections each in charge of an engineer who is responsible for the whole work of construction in that section, and who either indents for such rolling stock and engines as he may require or has a certain number allotted to him. A different organization was adopted on the Baro-Kano Railway, each distinct branch of the construction being placed under a separate engineer who was directly responsible to the Director of Railways. Thus the platelaying and traffic were placed under Capt. Mance, with Lieut. Maxwell in charge of the platelaying, and a civilian assistant traffic manager; the locomotive department under the writer of this article with two civilian assistants, and the bridging and earthworks respectively under two civilian engineers. This system has the undoubted advantage, where only a limited quantity of engines and rolling stock are available, that the greatest and most economical use can be made of them, which it is very difficult to do where the control is split up amongst various engineers. It also results in better care being taken of the engines. The men of the R.E. detachment were split up amongst the various departments according to their trades, the majority being in the platelaying party, but several were in the locomotive department and others employed on earthworks and maintenance.

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NOTES ON LOCOMOTIVE WORK.

The locomotives in use consisted of:—

Six 4-8-0 tender engines built by The North British Loco. Co.
Two 4-8-0 tender engines built by Hawthorne, Leslie & Co.
Two 2-6-2 tender engines built by Nasmyth, Wilson & Co.
Three 2-6-0 tender engines built by Hawthorne, Leslie & Co.
Three 0-6-0 tank shunting engines built by The Hunslet Engine Co.
Two 0-6-0 tank shunting engines built by Hudswell, Clarke & Co.

Thus it will be seen that no less than six different types of engines were employed. This was more or less unavoidable owing in great measure to the engineering strike on the North East Coast in 1908, but such reduplication of types should if possible be avoided. Spare parts for each separate type have to be kept not only at headquarters but at each running shed, some of which may never be used but must be ready to hand in case of breakdown as nothing can be obtained from England in less than two months. Three different classes probably would have been sufficient, one heavy and one light tender class for use on the main line, and one fairly heavy shunting class.

Only engines built by firms of the highest standing should be bought, owing to the rough usage to which they are subjected and which makes it imperative that only the best materials and workmanship should be used. Two instances occurred of newly-made banks subsiding under the weight of heavy engines, the engine in the one case turning over on its side and in the other turning over and sliding to the bottom of an 18′ bank. In the first case the engine was at work again within five days of being righted, and in the second the engine was taken into the shops and overhauled but had sustained no material damage beyond the breakage of a few minor details such as lamps, glasses, etc. In both cases had the materials or workmanship, especially of the boilers and frames, been in any way faulty, serious damage would have resulted.

The question of spare parts is a most important one, and to purchase a very complete supply of these, especially for the first year's work, is undoubtedly an economy. They can usually be turned out cheaper and better in England than in the local workshops, and in the case of such parts as cannot be made locally an engine may be laid up for a long time awaiting the arrival from England of some necessary part. This does not apply so fully in the case of brasses, bushes, etc., as, unless a large proportion of these are made locally, it is difficult to find a use for the scrap brass obtained from the old ones. Even in this case a complete supply should be stocked for the first year. The running sheds along the line must be kept supplied with a sufficient number of such spares for normal running requirements, and replenished as required. It is very useful if time permits to compile a "Normal Stock List" showing the normal stock it is

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proposed to keep on hand; this also simplifies the work of making up yearly or half-yearly indents. In these remarks, as in the previous ones, it is assumed that there is no large parent line or workshops close at hand from which stores can be obtained.

Ample storage accommodation also repays the extra expenditure as stores can then be properly sorted and looked after, whereas, where little space is provided for the purpose, there is a great liability to confusion and consequent waste.

The sections into which the line was split up were roughly about 110 miles long, a running shed being provided at the end of each section; this also constituted the normal run for an engine and its driver. These sheds were all provided with wheel pits in addition to the ordinary examination pit. The type used consisted of a concrete pit of sufficient depth to admit of a pair of driving wheels being dropped out clear of an engine standing over the pit. In the top edge of each transverse wall of the pit, a cross-girder was bedded into the concrete and to it were bolted the rail-bearing girders which took the weight of any engine passing over. The short lengths of rail across the pit were fishplated in the ordinary way and so both the rails and girders were easily removed after an engine had been placed in position over the pit. The wheels were then lowered by a long-screwed jack on to a trolley at the bottom of the pit, which was made sufficiently broad on one side to allow of the wheels being raised, if necessary, and taken away clear of the engine above. It is interesting to note how little use is made in England of wheel pits, the work of removing wheels being very often done by the clumsy method of jacking up the engine, which, unless care is taken, is also more dangerous.

Where Walschaert or other forms of external valve gear are used, a useful type of inspection pit is one which has a narrow pit running along each side of the main pit, the rails being carried on walls running between; the subsidiary pits are about the same depth as the main one. The men detailed to do any work on the gear can then stand to do it instead of having to kneel or even lie down as is ordinarily necessary.

Great difficulty was experienced in the last year's platelaying in keeping the engines on the northernmost section in decent running order, as the running shed and water supply at Kaduna were not completed until after railhead had reached Kano, by which time the main stress of the work was over. This meant that no proper running repairs could be carried out north of Minna which was 244 miles away from Kano. To get over this difficulty a temporary wheel pit was made at Kaduna; a site containing good firm soil was chosen and a pit of the ordinary dimensions excavated. This was lined with sleepers for its whole depth, the sleepers being held in position by rails driven as deep as possible into the ground, and anchored back. Girders and rails as for the ordinary wheel pit were

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used. This worked admirably as a temporary expedient for over three months, and enabled work to be carried out at Kaduna which would otherwise have had to be sent down to Minna.

The absence of any facilities for washing out engines at Kaduna presented more difficulties, as the water on the whole of the Kaduna-Kano section was extremely bad. This necessitated frequent changing of engines and sending them right back at first to Minna whenever washing out became necessary. Latterly this was remedied by an ingenious apparatus devised by one of the Assistant Locomotive Superintendents. On the North British Loco. Co.'s engines the clack box of the injector had a cock to shut off connection with the boiler, and also a screwed cap on top which could be removed for purposes of inspection. A coupling was made which screwed into the seating of the latter and coupled at the other end to a long length of armoured hose fitted with a wash-out nozzle. This coupling was attached to an engine under steam, the stop-cock to the engine having first been closed; then, when the injector was worked, it delivered a jet of water through the wash-out nozzle at very high pressure. The engine which was to be washed out was then pulled alongside the one under steam and could be washed out very quickly and efficiently. Another advantage was that the water used for washing out was very hot, and it was not necessary therefore to let the engine cool down before washing out which should always be done when cold water is used owing to the risk of damage to the boiler from the sudden change of temperature. The gear could be fitted to all the North British Loco. Co.'s engines, so that any engine of this class which happened to be available could be used to wash out any engine requiring it. The idea is a neat one, but can only be adapted for use with injectors having the clack box separate from the main injector.

The running sheds were fitted with the ordinary bench and forge together with a fairly large store and office for the foreman or driver in charge; the one at Minna had also a small foot-lathe and hand-shearing machine.

The main running arrangements were similar to the ordinary practice; an attempt was at one time made to let each driver have his own engine as it tends to make him look after it better, but it was found to be impossible during construction owing to scarcity of engines and cases of sickness amongst the drivers.

Each engine was at first fitted out with a complete set of tools which was handed over from driver to driver. But tools, such as spanners, were, as always, in great demand and had a mysterious knack of disappearing off the engine when it was near men belonging to other departments. A new system was then instituted; no tools were issued to engines, but each driver was given a locked-up tool-box fitted up complete with tools, gauge glasses, etc., which he took on to whichever engine he was detailed for, and for this box the driver

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was responsible. The results were excellent, the drivers liked it as they could rely on having a full kit of tools and very few tools disappeared after it was started.

Fuel.

When the line was projected it had been intended to burn coal, but the greater portion of the first year's supply went astray. It was therefore necessary to burn wood only at first, and the consignments of coal which did finally arrive were so small that mixed wood and coal had to be used. The results were surprisingly good, especially with some of the better woods, considering that the fire boxes had not been specially designed for the purpose. Even up to the end of construction, partly from motives of economy (coal at Baro costing 51s. a ton) but more largely owing to fear of shortage, mixed coal and wood were used except during the rainy season. On the shunting engines, where heavy steaming was not required, wood alone was used practically the whole time. For main line work the steaming qualities of the mixed fuel, although of course not to be compared with those of first-rate coal, gave sufficiently good results when it was used judiciously and the wood well seasoned. The main disadvantages were the sparks, the quantity of ash and the halts for re-wooding as a tender load of wood is consumed very quickly. Wood fuel was stacked at every watering station which were from 20 to 25 miles apart, and the gangs of woodcutters and water boys stationed at these places assisted in loading up. The usual quantity of coal allowed in these cases was about 20 to 25 lbs. per mile.

The cost of freight on the coal formed such a preponderating amount of the total cost that it paid to obtain the very best Welsh coal. This was done in the earlier consignments, but the wastage caused by the frequent rehandling from steamer to steamer was so great that quite an appreciable proportion was lost before it ever reached Baro, more especially in the case of Welsh coal which is very liable to crumble. Subsequently Patent fuel was obtained, the wastage in which was very small and which bears transport and exposure to weather very well.

Personnel.

The engine drivers met with on construction, especially in Africa are usually, I understand, rolling stones who go on from one construction job to another as they can earn better pay than on open-line work; they are a pretty rough class, unsteady and somewhat addicted to drink. The drivers on the Baro-Kano Railway, with the exception of eight N.C.O.'s and sappers, were drawn entirely from English railways; they were mostly firemen who had passed as drivers but had to wait some time before there would be vacancies for them as drivers, owing to the slow promotion.

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They were chosen very carefully both by examination of their previous records and by personal interview. They proved to be a remarkably steady and hard-working set, two essential qualities where men have to work very often "on their own"; in fact no single case of drink occurred during the whole time. The work was very trying and the hours long.

The firemen were natives, the majority of whom at the start had never seen a locomotive before, and, although they improved and will improve further as time goes on, they were never efficient. This of course threw a lot more work and responsibility on the drivers. The same drivers and firemen always worked together so that the driver reaped the advantage of any instruction he imparted.

Natives from the coast colonies were used for the shunting engines; in French West Africa native drivers are employed throughout, but, although the French native artizans appear to be more intelligent than the English coast natives, I think the white driver, although much more expensive, is more economical in the long run when repairs and upkeep of stock are taken into consideration.

WORKSHOPS.

The workshops at Baro were simple and inexpensive and call for little comment. The only item of special interest was the gear used for engine erection; this consisted of a tall gantry built up out of 12" × 12" baulks, the lifting tackle being a 15-ton differential tackle. This served its purpose but is now being replaced by a proper traversing overhead crane.

After the first year all wooden sleepers, joists, etc., were cut from local timber. The timber used most was a species of bastard mahogany; the forest was situated on the line about 20 miles north of Baro, where the sawmill was installed, the timber being brought down in the log. It was impossible to erect the sawmill on the actual site as it was too unhealthy. The mill consisted of a horizontal log band saw for splitting up the logs, a large circular saw with self-moving table, two smaller circular saws, a planing and surfacing machine, and the usual accessories such as saw-sharpening machines. The chief trouble experienced was in the warping of the timber due to having insufficient time which could be allowed for seasoning in order to keep up with the heavy demands for sleepers and scantlings.

An ice machine, a soda-water machine and a large condensed water apparatus were attached to the workshops and undoubtedly contributed largely to the comparatively clean bill of health.

Coast natives were employed in the workshops supervised by European foremen, but they were very inefficient and all special work had to be done by the white foremen. It is hoped in time however to institute a proper apprenticeship scheme for training the natives of the country but careful white supervision will always be a necessity.

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ECHOES FROM THE ENGINE ROOM.

By "INSPECTOR."

INTRODUCTION.

"INSPECTOR" has, for some time past, been concerned with pumping machinery ranging up to 80-H.P. and with various direct current electrical installations of small size.

These "Echoes" deal more particularly with the plants above referred to, but in order to harmonize them as a whole some use has been made of those valuable aids to the author of a technical pamphlet—"Scissors and paste."

THE PUMP FAMILY.

ECHO NO. 1.

PUMPS GENERALLY.

The pump family is a numerous one and it would be beyond the scope of these notes, as outlined in the "Introduction," to deal with all its many branches; attention is therefore confined to the more common varieties.

In order to avoid ambiguity it will be necessary to define briefly a few terms which, in pumping literature, have not always got a universally accepted meaning.

The terms "pump" and "pumping engine" are treated as being interchangeable although this may not be altogether accurate. The point is not of supreme importance. A triplex power pump certainly is a "pump" and not a pumping engine; the same may be said of a centrifugal pump, but what about the ordinary steam operated boiler feed pump? Strictly speaking the steam end of a pumping engine is a steam engine, and the water end is a pump.

It will be convenient to call those reciprocating pumps which have no rotary motion whatever in their main parts "straight line pumps." The smaller parts of such pumps may however have a semi-rotary movement *e.g.*, when fitted with valves of the Corliss type (see *Plate*).

Straight line pumps may be either simplex or duplex. The ordinary "Worthington" pump may be quoted as illustrating the

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latter class; of the former class there are several typical examples, made by such firms as Mumford, Weir, Evans and others.

There is some ambiguity in the meaning assigned to the term "direct acting" when applied to pumps. One of the merits that has been claimed for the "Worthington" type of pump is that it is direct acting. It is perfectly true that pumps of that type are direct acting, but the term is equally applicable to every pumping engine in which the pump rod forms a direct continuation of the steam piston rod, and it is suggested that the term is no less applicable to any pump in which the reciprocating movement of the piston rod is directly reproduced in the pump rod, without the intervention of cranks or levers between the two, whether the pump happens to be fitted with a flywheel or not, *e.g.* the ordinary wall Donkey Pump, and pumps of the "Cameron" type are examples of direct acting flywheel pumps.

The large variety in type suggests the conclusion that no one type is the best under all circumstances. As to which *is* the best for any particular case is often a debatable point. Some compromise is generally unavoidable since "best" may mean, in one case the cheapest, in another, the most economical in steam consumption, and so on. In considering the relative merits of different *types*, it must be presupposed that each type is equally well made. The fact, however, remains that, to some extent, certain makers have specialised in the manufacture of particular types and it is beyond question that some manufacturers can be better relied upon than others to use materials of the highest class. One is therefore, under certain circumstances, unavoidably oppressed with a feeling of uncertainty beforehand as to what type will best suit the requirements to be met. In that case it only remains to specify the duty which the pump has to perform, as well as the general and special factors in the case; select, if possible, the firms invited to tender; and then choose, from the offers received, that pump which is "best" having due regard to first cost, and guaranteed steam consumption, and possibly also to some other points such as simplicity and ease of erection.

One of the best examples in variety known to the writer is in the Hammersmith pumping station of the Metropolitan Water Board. Although the plant is on a large scale the station is well worth visiting by any one interested in pumping machinery.

This echo may be advantageously concluded by a postulate to the effect that, unless it is otherwise stated, all pumps between which comparisons are made are supposed to be in first-class working order. It is necessary to mention this in order to eliminate the uncertain variables due to wear; facilities for repairs and renewals; etc.

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ECHO NO. 2.

MISCELLANEOUS PUMPS.

(*a*). *Air Lift Pumps.*—Air lift pumps are not dealt with herein. The *Water Supply Manual* issued by the War Office in 1909 may be consulted. "Inspector" has come across but few pumps of this type in his wanderings, and the question does not seem to call for any business with the paste pot.

(*b*). *Hydraulic Rams.*—Hydraulic rams must unfortunately be classed with air lift pumps except that as the question is considerably simpler a few general remarks are perhaps permissible. (*Vide* also the *Water Supply Manual*).

Rams may be divided into two classes, "A" and "B." In "A" class the ram pumps part of the water which is supplied to work it. In "B" class the ram is arranged to pump water from one source when supplied with water from another source, but the suction lift of the water pumped should not exceed 5′ or 6′. "B" class can therefore be used to pump clean water and to be operated by (a larger volume of) dirty water.

The ratio between driving water and water pumped depends partly upon the design of ram, but chiefly upon the relationship between the head available for working the ram and that to which the water is pumped. If the former variable is neglected then the latter relationship may be expressed generally in the form

$$\frac{Q \times h}{q \times H} = \frac{7}{5}$$

where "Q" is the quantity of driving water, "h" the head under which it works, "q" the quantity of water pumped to a head "H." For example if H = 100′, and h = 10′, then substituting $\frac{1}{10}$ H for "h" in the above equation we get $q = \frac{1}{14}$ Q. In other words $\frac{1}{14}$th of the driving water is pumped to a height of 100′ if the driving head is 10′. This general rule is however approximate only since the greater the difference between "H" and "h" the less efficient will the ram be.

The driving head may be anything over 3′ up to one-half of the head pumped against. For a driving head up to 12′ the drive-pipe (or "flume") may be vertical but for higher heads it should be laid to an average gradient of 45° in order to avoid severe shocks on the body of the ram.

Rams may be adjusted to work with varying quantities of driving water down to $\frac{1}{2}$ the maximum for which designed. They should have gunmetal valves and seats, and must have large air vessels on the delivery side.

(*c*). *Express Pumps.*—Except to mention them as a modern branch of the family, "express" pumps are but briefly dealt with as

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they do not figure at present in "the engine room." By "Express Pump" is meant that class of reciprocating pump, in which the suction and delivery valves, or possibly only the suction valves, are mechanically operated, thereby rendering it possible to run the pump at a high speed *i.e.* quick revolution.

The Reidler and Oddie-Barclay may be referred to as types. The latter pump, manufactured by Messrs. A. Barclay and Co., Kilmarnock, has figured in the proceedings of some of the engineering societies, and has been used to some extent for mine work. It would seem that a pump which is capable of standing up to the trying conditions of mine-pumping should have got past the teething stage, and ought to be good enough for general purposes.

Although the "Hatfield" pump, made by Merryweather, is a quick revolution reciprocating pump it would not come under the category of "Express" pumps since its valves are not mechanically operated.

It may be remarked that it is practicable to run a pump at a relatively high periodicity if it has a large valve area, given by a number of valves with small lift, even though the valves are not operated mechanically.

ECHO NO. 3.

INJECTORS AND EJECTORS.

Injectors are principally used for feeding boilers either as a standby to the usual arrangements, or, in the case of small stationary boilers, as the normal device for the purpose.

They are made in a great variety of forms and types for different duties as briefly enumerated below.

Exhaust steam type for handling cold water against pressures up to 75 lb. per square inch.

Exhaust steam types with auxiliary live steam connection, capable of working against pressures up to 200 lb. per square inch when supplied with water not exceeding a temperature of 75° Fahrenheit.

Live steam types, lifting and non-lifting, and for "hot" and "cold" water.

Although the type and pattern of injector should be selected with special reference to the duty to be done, any of the standard leading makes are capable of working over a large range of pressures *i.e.* they will take steam from, and supply water to, boilers working at pressures ranging between 20 and 160 lb. per square inch.

Like injectors, ejectors are made for use with exhaust and with live steam. Apart from their use as air exhausters, referred to in Echo No. 17, live steam ejectors are principally of value in "the engine room" for intermittently removing water from sumps, etc.

Injectors and ejectors appreciably raise the temperature of the

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water passing through them. They are not efficient "pumping engines," but this want of efficiency is, to a great extent, counterbalanced if the arrangements enable the increased temperature of the water delivered to be made use of advantageously.

With steam at 50 lb. and a 20′ head an ejector will raise the temperature of the water about 20° Fah. Therefore theoretically $\frac{1100}{20}=55$ lb. of water will be lifted for every pound of steam. (*Vide* Echo No. 4). The steam consumption per P.H.P. hour may however be taken at between 800 and 1,000 lb.

Although, under many conditions of steam pressure and temperature of water, either device herein referred to will satisfactorily "lift" its water an injector should preferably be fixed so that the water supply thereto is given under a small head. For the live steam ejector it is usual to allow a small lift of 2′ or 3′ if the total head to be worked against exceeds the suction lift practicable having regard to the temperature of the water to be pumped. For both classes of apparatus the supply must moreover be given under a steady pressure; neither apparatus will work satisfactorily if the supply pipe to it is taken off the delivery pipe from, or supply pipe to, a reciprocating pump which is at work.

Makers' catalogues may be consulted as to such details as steam pressures, maximum lifts, heads, gallons per minute, temperature rise of water, etc.

Echo No. 4.

PUMPS OF THE SAVERY TYPE.

The best known type of "Savery pumping engine" is probably the "Pulsometer," but there are several engines of this type made by different firms such as the "Expulsor," "Aqua Thruster," and others.

Although a "pulsometer" is a very much more efficient apparatus for shifting water than is an ejector it is nevertheless not suitable for a permanent water supply. On the other hand a pump of this type is well suited for work of a temporary nature.

Makers' catalogues may be referred to details as to steam pressures, lifts, etc.

Steam Pressure (lb.)		Head, Feet.
30	.....	40
50	.....	80
60	.....	90

For suctions above 5′ a foot valve is desirable but if possible the lift should be kept low. For heads above 20′ a reflux valve should be fitted close to the pump. Air vessels on suction and delivery should be provided if the distances are considerable.

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Maximum head recommended is not more than 90′, although some types are made for lifts up to 150′.

For a lift of 20′ and with steam at 50 lb. pressure the temperature of the water passing through the "pulsometer" is raised about 4° Fah. If the number of B.Th.U. in one pound of steam at a pressure of 50 lb. per square inch is taken as 1,100, then this 1 lb. will raise the temperature of $\frac{1100}{4} = 275$ lb. of water 4° Fah. and theoretically 1 lb. of steam will be required for every 275 lb. of water lifted. The steam consumption per P.H.P. hour may however be taken at about 500 lb.

A "pulsometer," and its suction pipe, must be charged with water before steam is turned on.

ECHO NO. 5.

PISTON PUMPS.

The "thing" that pushes the water in a piston pump is so very similar to the piston of a steam engine that no special explanation as to the meaning to be assigned to the term "piston pump" seems necessary. In a pump however the piston is sometimes called a "bucket," although strictly speaking the term "bucket" should only be applied to a piston containing a valve, *e.g.* the bucket of a bore-hole pump.

Both in the steam cylinder and in the pump cylinder the piston itself is a comparatively easy fit in the cylinder, and in either case the piston must be packed in some way, in order to make it fit the cylinder closely. In the steam cylinder, as is well known, closeness of fit is attained by means of piston rings which are generally made of cast iron. This procedure would not be suitable for a water pump, as the rings would soon rust up and fail to efficiently perform their proper function. There is, however, a considerable choice as to the material to be used for packing the piston of a water pump *e.g.* leather cups, rope or other fibrous packing, rubber, ebonite, or vulcanized fibre rings or discs, and, for certain duties, metal rings. Leather and rubber are suitable for cold water only; neither is of any use if the pump has to work with hot water, in which case either ebonite, or vulcanized fibre, seems to give as good results as anything else.

If the pump is to be used with hot water, say 120° Fah. and over, the cylinder should be fitted with a renewable brass liner, and the pump rod should be made of bronze. The brass liner is useful in any case for a water pump, but its presence entails an increase in cost.

Piston pumps are used for boiler feeding for all ordinary pressures, and for "general service" for heads up to about 300′. They are not suitable for use with gritty water as the cylinder, or liner, cuts too quickly and the piston packing only lasts a short time. An exception as to their use with gritty water is however referred to under the heading of "Bore-hole Pumps."

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Echo No. 6.

PLUNGER PUMPS.

So far as concerns these notes, by Plunger Pump is meant that pattern of pump in which the business part of the pump, corresponding to the piston in a steam engine, consists of a hollow cylinder, the length of which is considerable in proportion to its diameter. The bore of this cylinder is closed in the middle by a stout partition to which is connected the pump rod. The pump chamber is divided into two similar parts by a diaphragm. The cylinder or plunger, slides to and fro in a deep sleeve which is bolted to the diaphragm above referred to. With the aid of a suitable metal packing ring, a watertight joint is made between the sleeve and the diaphragm ; the sleeve fits the plunger closely, the all round clearance between the two, when new, being of the order of 0·00025″ per inch diameter of plunger. No packing whatever is used between plunger and sleeve, and it is rarely necessary to refit the plunger and sleeve until the clearance between the two reaches ten times the figure given above. Ordinarily the plunger is made of cast iron and the sleeve of gunmetal or bronze.

With the arrangement described, no attention whatever is required for years if the water is clean and free from grit or silt. Further it is possible, within limits, to alter the size of the plunger used if the actual pumping conditions render such a course desirable. In one case with which "Inspector" was concerned new plungers, 50 per cent. greater in area than the original plungers, were fitted because it was found that the actual head against the pumps was considerably less than was anticipated.

This type of pump is referred to in the Worthington Pump Co.'s catalogue as the "Regular Pattern," or as the "Plunger and Ring" pattern and is regarded as suitable for heads up to 350′.

The piston-like "thing" above mentioned is legitimately called a Plunger, and therefore it is not unreasonable to call the pump concerned a "Plunger pump," even though the term may be sometimes used to describe pumps which are referred to in these notes as Ram pumps.

The pump rod is generally made of mild steel but the extra cost of bronze rods would often be justifiable, either when the pump is liable to be left standing for long periods, or if the water is at all corrosive. In either case what happens is that the pump rod corrodes, especially where it is not much polished by the packing in the gland, the rod then gets rough, and this roughness soon pulls the packing to pieces. "Inspector" has not, however, come across a "general service" water pumping engine with bronze pump rods, although many boiler feed pumps have rods of that material.

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ECHO NO. 7.

RAM PUMPS.

It is scarcely necessary to define here what is meant by a "Ram Pump" as the term is not ambiguous.

Whilst ram pumps can be used for all pressures, pumps of this type only, should be used for extra high heads. Ram pumps are also particularly suitable for use with gritty water.

The rams may be either of gunmetal, or they may be cased with that material, or they may be of cast iron; the class of water to be pumped is undoubtedly a factor in the case. The writer is acquainted with differential ram pumps with cast-iron rams which have been working satisfactorily for some years against a head of over 1,500′, and in another case the rams are of gunmetal and the head is over 1,400′. From this, one may conclude that the head has but little bearing upon the material to be used, although the textbooks rather favour gunmetal for the higher heads. As in the case of the rods of plunger pumps more important considerations seem to be (i.) the quality of the water and (ii.) to what extent the pump is likely to be left standing.

ECHO NO. 8.

DEEP WELL AND BOREHOLE PUMPS.

Deep Well and Borehole Pumps are dealt with at some length in the *Water Supply Manual*, but it seems permissible to make some supplementary remarks here.

Although water may not actually be within suction distance of ground level, it may sometimes happen that it can be obtained within the accepted limits of suction lift if the pumps are placed some few feet below the general level of the site. Three such instances are known to "Inspector." In one, a steam driven station, the boilers are placed at ground level and the pump room floor is 11′ below this. The plant is condensing, and the condensed steam is discharged at ground level by the air pumps direct without difficulty and without harmfully affecting the vacuum. In the two other cases the pumps are driven by oil engines, and in each case the engine room floor is about 10′ below ground level and the pumps are about 10′ lower; the drive between engines and pumps is by inclined belt. In other cases, if the vertical distance between pump and engine is small, an ordinary vertical type of pump can be driven direct off a vertical engine if the pump rods are suitably extended, up to a limit of about 15′ or 20′ dependent upon the size of the plant. This method of direct driving is applicable to any ordinary project provided the pumps are single acting on the up stroke *i.e.* as in the standard

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type of deep well pump. Double acting pump ends can only be used if the vertical distance is short.

By placing the pumps below ground level as suggested in the early part of the preceding paragraph, long pump rods are eliminated and the whole of the plant can be placed under suitable cover and can there be readily given proper supervision. However there are many cases when the pump must be placed down the well and be driven by rods from the surface. When so situated the barrels of the pumps should be made of brass or gunmetal in the smaller sizes or be "brass fitted" in the larger sizes, and in any case the pump rods themselves (*i.e.* not the well, or "spear," rods) should be made of bronze or similar material.

Having regard to the cost of constructing a well large enough to contain, and give access to, a well pump, pumps of this type are not ordinarily used for heads above 150′, and although such pumps could doubtless be made for any reasonable head, it is believed that 400′ is about the maximum for which they are constructed in practice.

If it is expected, or found by a trial boring, that water is not obtained within about 200′ below ground, a borehole pump would usually be provided in preference to one of the deep well type. It frequently happens, however that, by extending the boring, water is struck which will rise to within 150′ of the surface, and in such a case the storage capacity afforded by a deep well may be advantageous. (*Vide* account of Sheerness Water Supply in *R.E. Journal* for July, 1909). A decision as to whether to make use of a deep well, or a borehole, or a combination of the two, must be arrived at upon the merits of the case; but corresponding to the limit of 150′ as applicable to the deep well pump there is a normal limit of 300′ for the borehole pump, and although the boring itself may be considerably greater, it will not usually be justifiable to pump from a greater depth than 500′.

It is sometimes thought that a deep well pump will only work when above water. That is not so, but the trouble is that if it breaks down when submerged it may be difficult and costly to recover. A borehole pump, on the other hand, is constructed to work submerged and is so arranged that the rods, and bucket can be drawn up for inspection and repair, and the clack or bottom valve can also be "fished" up and replaced.

Deep well pumps are generally driven by rods off a "top gear," consisting of a well frame, crankshaft, gearing and possibly fast and loose pulleys for a belt drive. The driving power may be electric motor, oil engine, or steam engine, but in every case, unless the space available is insufficient, a belt drive should be used between the motive power and the top gear.

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The "spear" rods need guiding at about 10′ intervals to prevent swaying and other irregular movements. The type of guide will depend upon the design of rod adopted, but the simpler the guide the more likely is it to be satisfactory in operation.

In some cases the pump is fixed in a dry well excavated alongside the well proper. This entails extra cost, and seems to be quite unnecessary. With reasonable precautions there is no reason why the water in the well should be polluted either by oil from the pump gear, or otherwise, even though the pump is fixed in the well itself.

A characteristic feature of the Borehole Pump, compared with other reciprocating pumps, is the length of stroke relatively to the diameter of the bucket. The amount of space available in the bucket for valves is strictly limited and therefore rapid reversals in direction are inadmissible. Consequently, if a considerable delivery of water is required, a long stroke is essential. A "straight line" engine is the best for driving a long stroke borehole pump, and can be obtained cheaper than any flywheel engine of equal quality for the same duty. Moreover it can, if necessary, be readily fitted with suitable pausing gear which enables the valves to seat properly at the end of each stroke before the return stroke commences.

It is scarcely to be expected that a deep well pump will receive such careful attention as a surface pump, and in the case of a borehole the pump cannot be examined without withdrawing it; hence in neither case is it desirable to put more work upon the below ground pump than is unavoidable. If the total head, from water level to point of delivery, does not exceed 150′ it may be effected by one lift, but even in this case if the size of plant exceeds 15 P.H.P., and certainly in most other cases when the total lift exceeds 150′ it is preferable that the below ground pump should deliver the water into a sump or tank at ground level only. From this sump the water is pumped by an altogether separate pump to the distribution reservoir or other point above ground level. Both pumps may be driven off the one engine.

In all cases of pumping from wells or boreholes there is likely to be a good deal of grit in the water at first, and therefore, if the permanent plant must be used for dealing with this water, it is desirable to allow the bucket to be a comparatively easy fit in the pump barrel to start with; the slip of the pump may be high, for the time being, but the bucket and barrel will be saved from excessive wear. This suggestion only applies to bucket pumps.

In concluding this echo it is only right to say that a more liberal use has here been made of the scissors and paste-pot than in other cases, as "Inspector" has had but little to do with deep well pumps and nothing to do with borehole plant.

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Echo No. 9.

CENTRIFUGAL PUMPS.

Although so far as is known, there is no really good literature dealing in popular language with centrifugal and turbine pumps, no comprehensive attempt to remedy the deficiency is intended here.

Since the introduction of turbine pumps there seems to be a tendency to regard such pumps as the best for all requirements. Before the advent of the modern turbine pump, centrifugal pumps could only compete satisfactorily and economically with reciprocating pumps when the conditions necessitated large quantities of water delivered against relatively low heads. For such requirements the centrifugal pump still holds its own, and the improvements in the designs of the centrifugal pump which led to the evolution of the turbine pump has enabled such pumps to be used with advantage under a considerably extended range of conditions, but by no means universally.

The head against which a centrifugal pump will deliver water depends upon the peripheral velocity of the impeller, the relationship between the two being deduced directly from the formula $V = \sqrt{2g.H}$

A lift of about 100′ was about the maximum for which ordinary centrifugal pumps were constructed, and although the usual lifts were considerably lower than this it was possible by coupling up two or more pumps "in series" to reach heads much in excess of 100′.

Although various manufacturers of modern turbine, or "high pressure" centrifugal, pumps claim special merits for their own type, it is questionable if there is much to choose, in any way, between the best of the different makes. The turbine pump seems to owe its development to a combination, of the "Venturi Law" and the centrifugal pump. There is little doubt that the efficient conversion of velocity into pressure entails carefully made and exceedingly smooth passages in the pump. It seems equally certain that the efficiency of a turbine pump depends greatly upon the correct form of the blades of the impeller.

In turbine, or high pressure centrifugal, pumps the series arrangement above referred to is still adopted for high heads, but in modern pumps the various impellers are enclosed in a suitably designed single casing.

Practical considerations limit the number of r.p.m. at which it is desirable to drive an impeller of a given diameter. This reason, amongst others, enables a single large impeller to be used for heads up to 400′ if the quantity of water to be delivered is large, but if the quantity is small, entailing the use of an impeller of small diameter, the head attainable by a single impeller, is more than correspondingly reduced.

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A general rule may be deduced from the above considerations to the effect that a centrifugal (or a turbine) pump should only be used if the number of gallons to be delivered per minute is equal to or greater than the total head. The charming simplicity of this rule leads one to suspect its justification on scientific grounds, but it may nevertheless be taken as a useful general guide.

Apart from the limited use of centrifugal pumps for handling large quantities against low heads, *e.g.* drainage, irrigation, dock, and salvage work, circulating the cooling water for condensers, etc., their descendants, turbine pumps, are most largely used in connection with electrical power schemes. The speeds at which it is necessary to drive turbine (and also centrifugal) pumps render them suitable for direct coupling to electric motors, especially to A.C. motors the efficiency of which is best at high speeds.

As a pumping engine the efficiencies of centrifugal and turbine pumps compares unfavourably with corresponding figures for reciprocating pumps, except when large quantities of water have to be pumped against very low heads. All centrifugal and turbine pumps attain their maximum efficiency, for every speed at which they are driven, for a definite number of gallons and for a definite head. If we take the total head as being dependent on the speed, or conversely, then if while the speed remains constant, the head varies the output of water will vary greatly—especially in the case of centrifugal pumps, less so as regards turbine pumps. Alteration of head may for instance, occur by a change in the level, of the water on the suction side, and if, for example the normal suction lift of 15′ is reduced to 5′ the effect will be a very greatly increased delivery of water from the pump and a *considerable increase in the B.H.P. required to drive it at a constant speed.* This peculiarity means that the motor, or other thing which drives the pump, must have a considerable margin of power, *or else the delivery from the pump must be controlled by a sluice valve* whereby the total head against the pump can be increased to compensate for a reduction of head on the suction side.

If "H" is the total head in feet, "G" the gallons delivered per minute, and "R" the revolutions per minute at which the pump is driven then two of these three quantities are related to one another, approximately, by the following expressions, the third quantity being constant.

G varies as R.
G „ „ $\sqrt{H}$.
H „ „ R^2.

Although a turbine (or centrifugal) pump will handle gritty water it will not do so without wear. If the head is high, entailing a high

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peripheral velocity of impeller, the wear on the blades will soon bring down the efficiency of the pump.

When once started, a centrifugal pump will operate satisfactorily with any ordinarily "lift" on the suction side, but both it, and its suction pipe, must be fully charged with water before the pump is started. To facilitate this charging the suction pipe should have a foot-valve, and a sluice valve should be fixed in the delivery pipe close to the pump. The sluice valve also performs another useful purpose; if it is closed, as it should be, when the pump is started, the pump is prevented from discharging any water and consequently the load on the pump is small. This enables the pump to be started up "light" and then by gradually opening the valve the load is brought on quietly. Further if the valve is closed before the speed of the pump is reduced there is a reasonable chance that a full charge of water will be retained in the rising main, which will probably facilitate "charging" before the work is again started.

Echo No. 10.

POWER PUMPS.

By the term Power Pump is meant a pump of that class which has one, two, or three, rams or pistons, driven off a crankshaft which is in turn driven by some source of power exterior to the pump itself.

Generally speaking some form of single reduction gearing forms an integral part of most power pumps, but if the head is a low one and the pump is small it may be possible to omit the gearing. On the other hand in the case of large pumps working against high heads it may be necessary to provide double reduction gearing.

Power pumps may be of the vertical or of the horizontal type and although standard power pumps are made in the vertical form for high heads and large outputs some makers prefer the horizontal pattern if the output is considerable, especially if the head against the pump is large. This seems a sound principle to follow, for whereas the vertical type is the more economical in floor space the horizontal type can be made more rigid and is, in the larger sizes, more readily accessible. If this view is accepted then it may be taken as a guide that wherever the available floor space permits it is preferable to use a horizontal type of pump for all heads over 350′ and for three throw pumps with rams over 6″ diam. × 9″ stroke. It is not intended to include hydraulic pressure pumps in this generalization; although such pumps are constructed for working against very high heads (or pressures) the quantity of water to be pumped is, as a rule, relatively small, and in practice it is apparently preferable to make these pumps in the vertical form.

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The simplest pumps of this class have hollow rams similar to the trunk piston of an ordinary internal combustion engine. Such pumps are suitable for heads up to about 350′. For higher heads the outer end of the ram should terminate in, or be rigidly coupled to, a cross-head, which moves in suitable guides similar generally to the crosshead guides of a steam engine. There is a considerable variety in the designs followed as may be seen on reference to the catalogues of different makers.

As to whether the pump to be installed should be single throw, two throw, or three throw will ordinarily be settled by the quantity of water to be pumped. It may happen however that it is important either that large fluctuations in the flow of water must be avoided or that uniformity in the load against the driving agency is desirable ; in such cases the merits of the three throw pump over the other classes deserve consideration. It would generally be desirable to adopt the three throw pump for water supply purposes, or for boiler feeding.

The bearings generally should be adjustable and, if the pump is to be fixed in an out of the way place, should be readily renewable. For the smaller sizes of pumps with hollow rams less than 6″ in diameter the gudgeon pin bush is not usually adjustable, and in some designs with white metal main bearings the bearing metal is run direct into the recesses, formed for the purpose, in the framework of the pump ; neither of these practices is to be recommended for a pump used for a permanent water supply far removed from workshop facilities.

Cast-iron rams are good enough for most cases, but brass-cased, or gunmetal, rams can be fitted if necessary, as in the case of other ram pumps.

In the case of 3-throw pumps the number of bearings to be provided for the crankshaft depends partly upon the size of the pump and partly upon the head to be worked against. The practice of different makers varies so much in this respect that no definite limits can be given ; the smallest pumps have only two bearings, and the largest have four, or even five, crankshaft bearings, both in the vertical and horizontal types.

In the case of single reduction spur gearing although some makers employ cast iron both for the spur wheel and the pinion, the standard practice of other firms is to make the pinion of steel. Since the wear which is distributed over the many teeth of the spur wheel is concentrated on the few teeth of the pinion a case-hardened forged steel pinion is preferable to one of cast iron for a permanent job.

A small point in the working of hollow plunger power pumps which is apt to be neglected is the lubrication of the gudgeon pin. In horizontal pumps of this type a lubricator can be secured to the connecting rod and the oil carried by a small pipe, clipped to the rod,

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to the gudgeon pin bearing. In pumps of the vertical type the bottom of the plunger may be filled with oil to a depth sufficient to insure the lubrication of the moving parts. But in these pumps the plunger is sometimes made so short that its top edge comes just below the level of the top surface of the gland when the plunger is at the bottom of its stroke and if the stuffing box has been packed rather full. When this happens some of the leakage past the packing trickles over inside the plunger at every stroke and the water soon displaces the oil from the neighbourhood of the gudgeon pin.

The *Water Supply Manual*, already referred to, suggests the desirability of providing power pumps with a by-pass. In the case of pumps positively driven by oil engine or electric motor such a device is a necessity unless there is a friction clutch between the pump and the driving agency. In the case of a pump driven by a steam engine, or by belting and fast and loose pulleys off either an electric motor or an oil engine a by-pass is not required for sizes below 25-P.H.P. and its provision only adds needlessly to the cost of the pump. A steam engine can always be started up quietly under load, and in the case of a belt drive with striking gear the oil engine or electric motor can be started up "light." Large pumps would however usually have a by-pass, and when direct driven by A.C. motors of 50-B.H.P. and upwards a by-pass becomes a necessity, more particularly so when the head against the pumps is a high one.

As is the case with other types of pump, the efficiency of a power pump increases with the size. The following figures may be taken as a guide :—

P.H.P.	Efficiency.
Below 5	50 per cent.
5	60 „
10	65 „
25	70 „
100	75 „

Echo No. 11.

AIR PUMPS.

Mention must be made of the "Edwards" air pump as that type of pump is so universally used now. It is believed that this pump made its *début* on "tramp" steamers, but to the average landsman it is probably best known as a valuable accessory in electric power stations. In such stations the Edwards air pump is generally operated at fairly high speed, 150 r.p.m. or so, but it may be useful to know that this type of pump will also give satisfaction at speeds as low as 20 r.p.m.

The "Worthington type" surface condensing pumping engines

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manufactured by Messrs. J. Simpson & Co. of London and Newark are fitted with air pumps of the "Plunger" type, with cast-iron plungers working in gunmetal sleeves. The oil carried over from the steam cylinders with the exhaust steam adequately lubricates the moving parts, and it is found that this type of air pump can be relied upon to give every satisfaction under those conditions. The wear is small and repairs are easily carried out.

In Echo No. 17 mention is made of the necessity for providing some means of exhausting the air from the suction chamber therein referred to. Where steam is not available, some form of vacuum pump would be required if exhausting arrangements were essential. Such pumps are readily obtainable for driving by hand or by power.

Recently high speed centrifugal pumps of special design have been employed as air pumps. The Leblanc pump may be quoted as an example. In order to enable this type of pump to operate as a vacuum pump it is necessary to supply it continuously with a certain amount of injection water whereby the air is trapped and so discharged by the pump. The injection water can be used repeatedly over and over again.

(To be continued).

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TRANSCRIPT.

THE ROYAL ENGINEERS OF THE TERRITORIAL FORCE.

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The importance of the engineer services to the efficiency and well-being of an army in the field can hardly be overestimated. Modern inventions and methods of warfare all tend to magnify the *rôle* assigned to the engineer. The more science is brought to bear upon, and adapted to, the service of war, the greater is the part played by the technical corps of an army. It is, however, often not thoroughly appreciated how all the specialized branches of the army—artillery, engineers, medical corps, and even cavalry, are designed and used really in the service of infantry, "the pith and strength of battle." The infantry is the arm which has ultimately to decide the conflict, and to fight and win or lose battles. The *raison d'être* of the other branches of the Service is to cover, protect, and assist the infantry when and where required, and to enable it to maintain the position taken up, or, if necessary, to perform similar duties during a retirement.

Each arm—cavalry, artillery, and infantry—has a power peculiar to itself, yet is dependent to a greater or less extent upon the co-operation of the other arms. They all require and rely on the assistance of the Royal Engineers, whether in the arrangements for camps and bivouacs, building and demolition of bridges, communications, provision of entrenchments and fortifications, to name a few of the duties devolving upon the engineer corps.

General Sir John French, G.C.B., Inspector-General of the Forces, in the course of his address to the cadets at his recent official inspection of the Royal Military Academy at Woolwich, especially emphasized the increasing importance and greater necessity of the services of a highly skilled corps of Royal Engineers, under modern practice and conditions of war. The British Army at present is allotted a smaller proportion of engineers than is the case in many of the great foreign armies. During the South African and Manchurian Campaigns the necessity of highly-trained and efficient engineer services was more marked and realized than ever before. Whilst the great principles of war remain, as always, immutable, modern weapons and conditions have revolutionized the practice; and consequently the art of the engineer, and, indeed, of all the so-called scientific or technical services, is called upon to an extent not previously contemplated. The Territorial Army is an integral part of the Empire's defences, as our military forces are now organized. We desire to direct the attention and interest of engineers in civil life to the Royal Engineers of the Territorial Force.

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The organization of the Territorial Force is that of an army intended for war. It provides for fourteen divisions, with the proper number of corps and army troops. A division at full strength consists roughly of 20,000 officers and men. To each division is allotted its quota of Royal Engineers, in accordance with the establishment, known as the Divisional Engineers, consisting of two field companies and a telegraph company. In addition to the Divisional Engineers, whose headquarters are situated in various parts of the country, there are wireless, cable, and air-line telegraph companies. These latter may be said to be divided into five groups—one group in each of the London, Northern (Leeds), Scottish (Glasgow), Southern (Birmingham), and Western (Liverpool) commands. There is a balloon company, with headquarters in London, and a railway battalion at Crewe. The force further includes fortress engineers, and works and electric-light companies, situated in different parts, and electrical engineers in London.

In the monthly army list, published by authority, and obtainable through any bookseller, price 1s. 6d., will be found a complete list of the various Royal Engineer units of the Territorial Force, with the addresses of the various headquarters and names of officers serving. It will be seen that a complete organization has been worked out and established, and that opportunities exist for engineers to assist in the defence of the country by serving in the Territorial Army, and particularly in the Royal Engineers branch of that force.

Now it seems clear that officers of the Royal Engineers in the Territorial Force ought to be engineers in civil life, apart from any military training, or at least ought to have had a sound engineering training. The regular Royal Engineer officers are the most highly trained and carefully selected of all the officers of the Army. We understand that in the Territorial Royal Engineers large numbers of the commissioned ranks are without any engineering training, or experience, in civil life, obtained directly from following some branch of engineering or any of the allied vocations.

We realize the difficulty there is in obtaining a full supply of suitable candidates for commissions in all branches of the Territorial Force. We admire the energy and patriotic spirit of those who, having no connection with engineering, hold commissions in the Territorial Royal Engineers. Under present circumstances, no doubt, without them the force could not have been raised. In our opinion, however, it is a *sine quâ non* that if the Territorial Engineers are to approach and maintain the required standard of efficiency they should be officered by men with engineering training in civil life. In some few instances we believe commanding officers of engineers insist on some engineering or allied qualification on the part of candidates they recommend for commissions under their command. This course, instead of being the exception, ought to be the rule. An ample supply of men with the necessary qualifications is available; nobody can seriously dispute this. Anyone sufficiently interested may, by application, obtain a very good knowledge from the manual of military engineering and certain drill books, and up to a certain point may make himself a good officer. But he is not and cannot pretend to be either an

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engineer or an engineer officer in the proper sense. It would be easy to enlarge at length on the subject and point out many reasons why Territorial Royal Engineer officers ought, from every point of view, to have had some training and experience to fit them for their duties other than that obtainable on the Stock Exchange, in a lawyer's office, or other spheres of life totally removed from anything connected with engineering, buildings, or allied employments. We have not, however, space to do more than draw the attention of engineers to the matter. Most men have friends in the Territorial Force, and it is a simple matter, for anyone who will take the trouble. to find out full particulars.

The question of expense is sometimes a difficulty, but it is often exaggerated. The pay and allowances received when in camp will more than cover the annual expense incurred. On first joining probably an expenditure of £20 to £25 will provide all that is necessary in the way of uniform, etc., at any rate, for the first few years of service. After, say, a couple of years or so, a few extra pounds may be expended to make the kit more complete. The old extravagant methods and notions that existed in many volunteer regiments, and the constant drain on the pockets of officers in subscriptions to various regimental institutions, suppers, etc., are things of the past. Of course, a few regiments still exist in which it is somewhat expensive to hold a commission, but they are decidedly few, and even in these expenses have been reduced from what they were in volunteer days. Much useful information to anybody thinking of applying for a commission in the Territorial Royal Engineers, or any other branch of the force, is contained in the *Regulations for the Territorial Force and for County Associations*, 1910, obtainable for 6d. from any bookseller. Conditions of service, particulars as to pay, training, necessary uniform, with much other information, together with a copy of the Territorial and Reserve Forces Act, 1907, are included in this official publication.

Any candidate for a commission can obtain any particulars he may wish for from the secretary of his County Association, or from the adjutant of a local corps. A man who is thinking of applying for a commission will probably know some officer who will advise him, or tell him, how to set about it. In the event of his not knowing any Territorial officers, he should make an appointment to see the Secretary of the County Association, or the adjutant of the corps or regiment in which he wishes to apply for a commission. The adjutant will give any information, and explain the regulations and conditions of service, and arrange for an interview with the colonel or officer commanding. If the latter, after making enquiries about the candidate, considers him suitable, he will, when a vacancy occurs, recommend him for a commission, which, in the ordinary course, he will then receive.

No member of the Territorial Force can be compelled to serve, unless he volunteers to do so, outside the United Kingdom of Great Britain and Ireland. He must attend the minimum number of drills per annum laid down, which, in the Royal Engineers, is forty-five before the end of the first year of service, and fifteen in subsequent years, and he must also go into camp with his unit once a year for not less than eight days, and not

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more than fifteen days. If, however, some real and *bonâ-fide* reason arises why he cannot attend camp, the officer commanding can, in his discretion, grant leave of absence, and this is never in practice unreasonably withheld. During camp training all ranks receive Army rates of pay and allowances. A second lieutenant Royal Engineers draws 15s. 1d., increased to 17s. 1d. when he has passed for promotion to lieutenant; a lieutenant, 18s. 4d.; and a captain, £1 5s. 8½d. a day; but to be eligible to draw pay and allowances the minimum number of drills for each year must have been completed before going to camp. A drill consists of one hour's instruction, and any number of drills up to three may be performed in one day.

Before promotion to the rank of captain, the officer must attend a course of one month's duration at the School of Military Engineering at Chatham. This course may, however, if necessary, be spread over two years, a fortnight being taken at a time. Travelling expenses to and from Chatham are paid, and the officer receives the rate of pay and allowances, at Army rates, of his rank whilst attending the school of instruction. Further, if he passes a satisfactory examination at the termination of the course, an outfit allowance of £20 (in addition to pay, etc.) is granted, which goes a long way to meet the expenses incurred in buying uniform immediately upon receiving his commission.

In the event of great national emergency, and after the Army Reserve has been called to the colours, the King may issue a proclamation embodying the whole or part of the Territorial Army. In this event those called upon would be obliged to respond or be treated as deserters. The proclamation would not take effect if both Houses of Parliament presented a petition praying that the force should not be called up.

Arrangements are made whereby an officer who has temporarily to change his place of residence can be attached to a local corps for the performance of the necessary drills, or in the event of the change being permanent, can, when a vacancy occurs, exchange into another corps, provided the various commanding officers concerned approve the transfer. In the event of an officer having to go abroad, and wishing not to relinquish his commission, he may be seconded for four years from the termination of his first year's absence, if recommended by his commanding officer. If residing in a British Colony, or in Egypt, the officer may, on being recommended, be attached to a regular or local corps, for not more than two years in succession, for the purpose of carrying out any portion of his annual training. All officers of the Territorial Force are interested in and enjoy the work. Many are very keen and efficient, and devote much time to their military duties and education. The attendance required by the regulations is not enough to make a good or useful officer. The great majority do far more than the minimum laid down. These men find they can do it and choose to do it, and it is therefore difficult to believe that, with few exceptions, others cannot do likewise. Instead of a shortage of officers, there ought to be a list of candidates waiting for commissions in the Territorial Force, and particularly in the engineer branch. All ranks of the Territorial Army are, under the Act of 1907 constituting the force, exempt from jury service.

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REVIEW.

PERMANENT FORTIFICATION.

By Major von Brunner. Translated for the General Staff by Capt. R. Walker, R.E.

This book has been selected for translation, as being a standard text-book in the Austrian Service, which has passed through seven editions.

It has been written for use in the Imperial Military Training Establishments, and for the instruction of officers of all arms. It does not therefore aim at being an exhaustive treatise on the subject.

The book contains only 99 pages, but the author, by confining himself strictly to the most modern practice of fortification, and by omitting all historical information and descriptions of more or less obsolete types of forts, has succeeded in condensing as much instruction as possible into the space available.

The greater part of the book is taken up with the protection of land fronts of fortresses, only 14 pages being devoted to coast defences. This latter portion has been abridged from the original, which is perhaps to be regretted, as it is the branch of the subject which is of more direct importance to the British military engineer. There are very few modern works on fortification written in the English language and some of these deal rather with principles than details of construction, and in some cases advocate particular theories. A book therefore which describes existing practice, and furnishes particulars of the types of works which are actually constructed on the Continent at the present time, is likely to prove very useful.

The illustrations are incorporated with the text and are necessarily of small size. They are however in most cases reductions to scale of working drawings, and the scale, and where necessary the levels, are given. They would therefore be of considerable assistance in preparing the designs for similar works.

General particulars are given of iron turrets and cupolas, and in accordance with Continental practice these are introduced into all the designs of permanent works for land defence. Other features of the typical designs of detached forts are simplicity of trace, the substitution of steel palisades for the escarp wall, the reliance on counterscarp galleries for the defence of the ditch, and the provision of parapets only for the use of infantry in the final stages of the siege.

A section of the book is devoted to the use of fortification in mountainous regions and the design of barrier forts and auxiliary arrangements for the defence of mountain passes.

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In the coast defence section the proposals for the protection of harbours from naval attack are of the most complete description, and include not only heavy guns up to 12″ calibre, but also light and medium armament, defence lights, an outer defence of naval mines, a minefield at the entrance to the inner harbour, a boom where practicable, and batteries on shore for discharging locomotive torpedoes.

It may be noted that though armour protection is advocated for coast batteries it is considered relatively of less importance for them than for land defences, more especially in the case of coast batteries on high sites.

Coast fortification even to a greater extent than land fortification consists largely in the proper employment of engineering appliances of a mechanical nature, and it is not possible in the small space occupied by this portion of the subject for the author to do more than mention the general arrangements recommended for defence.

For particulars of the various appliances, which are proposed for employment, it will be necessary to consult other books.

Permanent Fortification for the Imperial Military Training Establishments and for the Instruction of Officers of all Arms of the Austro-Hungarian Army. By Moritz Ritter von Brunner, Major, Engineer Staff, Austro-Hungarian Army. 7th edition; completely revised, 1909. Translated for the General Staff, 1911. Price 4s.; 99 pages.

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NOTICES OF MAGAZINES.

Neue Militärische Blätter.

April, May, June, July, 1911.

(1). Is Germany in Need of a Fleet?—A long and interesting article is given under this heading, discussing the *pros* and *cons* of a large sea force of which the following is a brief *résumé*:—

Forty years ago Germany was an almost exclusively agricultural state, to-day industry and commerce have increased enormously in importance. Forty years ago the population of Germany was 40,000,000 souls, to-day it is 65,000,000, and is increasing yearly at the rate of 900,000. The increased industry and commerce have created new needs. Raw stuffs are required which home products alone cannot supply; more food stuffs are required to feed the increased population; consequently the mercantile marine has increased in importance.

Forty years ago England alone ruled the seas and had all the overseas trade in her hands, since then she has had to fight the Germans in the fields of trade and between them England and Germany share the trade of the world.

Thus the protection of her trade and trading vessels is Germany's first reason for the possession of a fleet: the protection of her coast is a second reason. It is not uninteresting to notice that the author lays down that this protection is best carried out by offensive action on the high seas, and adds that it is to the above causes, and not to any ideas of attacking England, that the fleet owes its existence.

An objection was recently raised in the Reichstag that the fleet merely caused an increase in the British Navy corresponding to increases in the German fleet, and thus led to the expenditure of more money than ever on armaments. Further that the increase in importance in the navy was having a bad effect on the army, which always had been and always should be the backbone of Prussia's might. It was also stated that, whereas England had to keep up a large fleet because all her food stuffs came from over the seas and therefore loss of sea power would mean starvation to her, Germany could get supplies both overland and from the country itself.

The arguments against this objection were that although the internal industry of Germany is considerable, it is to a large extent dependent on

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the supply of raw material which comes from outside. Were this to cease numbers of factories would have to close down, and unemployment would be rife in the land. This means that Germany must have a fleet to protect her overseas trade.

It were equally sound, it is objected to the arguments of this deputy, to abolish the army on the grounds that a war with France is no longer likely, the peace of the whole world being ensured on the principle of a "commercially united Europe."

That this unification will ultimately take place, ends the writer, there can be no doubt, but it will not be till after many fights.

ENGINEERS AND PIONEERS.—This article is an appreciation of the engineers' and pioneers' present position in the Germany Army.

Up to the present it has been rather the custom to look down on the engineer officer, mainly, perhaps, because of his necessary connection with things that are not purely military, in a word on account of his "D.O. work." The necessary result of such employment is to lead the officer to forget more and more that he is a soldier and hence deprive him of that spirit of the offensive with which every fighting man should be imbued. Permanent practice in the building of defensive works and fortifications tends to make him think of defence alone. It must, however, be remembered that a fortress is after all but an artificial means of strengthening a place, and thus reducing the number of men required to defend it so that more men can be employed in the field armies at some more threatened spot. It is therefore almost a weapon of offence, and the modern method of fortification increases this characteristic in that modern fortresses consist of battlefields strengthened at intervals by permanent works. All these factors are now bearing fruit, and the true use of the engineer is being slowly discovered as is shown by his attachment at present to the staffs of higher units on manœuvres.

Of late it has been the custom to call the pioneers the fourth arm. This practice is as false as that of designating them as the "technical arm." An "arm" possesses a distinct weapon; the infantry are armed with the rifle, so are the pioneers and communication troops, therefore it is only fair to consider them as infantry. They have received, it is true, a special training, but this does not authorize the use of the new appellation any more than does the statement that the spade is their weapon. A spade is a tool, not a weapon, and besides this its use is no longer confined to the pioneers only, every infantry soldier carries one.

Napoleon said: "A gun, bread, ammunition and entrenching tools, are things without which a soldier should never be." Modern tactics have merely increased the importance of taking and making cover. The days are now long since passed when the pioneer company was automatically detailed as escort to the guns; the F.S.R. lay down:—"Pioneers should as a rule accompany the advance guard." And again:—"Pioneers will also as a rule be allotted to the outposts, to strengthen the position, block approaches, etc."

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Pioneers must necessarily specialize amongst themselves; thus we already possess infantry and cavalry pioneers, the special task of the latter class being the rapid crossing of streams by means of light bridging material. Moreover the day will soon come when the artillery pioneer will spring into existence.

Finally, in fortress warfare the pioneer is even more indispensable than in the field, and it is a very great pity that the bridging trains are not given teams in peace time to drag their bridging equipment, a neglect which cannot fail in the highest degree to adversely influence their efficiency in war.

Changes in the Administrative Services of the Russian Army.—The percentage of employés of various ranks of the administrative services in the Russian Army is 50 per cent. smaller than in that of any other European nation.

The work they carry out includes that done by our A.O.D. and A.S.C. with this difference that hitherto no arrangement has been made to allot any of the staff of these services to the higher units. This is the first change that is being aimed at, and to supply the *personnel* which will be required to effect this reform it is proposed to obtain the services of officers of the army. They will receive a special course of instruction, partly theoretical and partly practical, which will last three years. Regulations still remain to be made as to the rank these officers will hold, the conditions of service, promotion, retirement, etc., as up to the present there has been nothing laid down on these subjects, and what few rules exist are merely local.

The minor positions in this corps will continue to be occupied by men of little education as before, only the higher ranks are being changed, or, more properly speaking, established.

The Colonial Army of France.—Public interest in France has recently been focussed on the colonial army, the more so as portions of this force have been employed in the recent campaign in Morocco, so that it is, perhaps, not amiss to give a short account of its strength and composition.

The French colonial possessions are 11,000,000 of square kilometres in area, and contain some 50,000,000 inhabitants.

Not including Algeria and Tunis, which curiously enough do not count as colonies, they are composed as follows:—(1) Indo-China; (2) West Africa; (3) East Africa; (4) The Antilles; (5) the possessions in the Pacific (New Caledonia and Tahiti).

The object of the colonial forces is to garrison and protect these colonies, and, in case of need, either to protect France or take part in oversea expeditions.

These troops are quite independent of the rest of the French Army and possess their own body of officers and their own administration. The army in France comes under the War Minister, but the troops situated in the colonies are under the Colonial Office as regards their

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administration, repartition and employment. They are composed partly of French (white) troops and partly of native levies.

Firstly as regards the white troops. These consist of infantry and artillery, of which an army corps (36 battalions and 3 artillery regiments) is in France, garrisoned at Paris, Rochefort, Toulon, Brest and Cherbourg and the remainder are in the colonies. Some companies of A.S.C. drivers (compagnies de conducteurs) are also attached to the artillery. With the exception of a few native troopers in West Africa, there is no cavalry.

The total strength of the troops in the colonies is 54,000 men, of which 34,400 are natives and 19,600 whites. To these may be added a few troops of the regular French Army belonging either to the Foreign Legion or to the Engineers. If to the above be added the native Algerian and Tunisian levies, a total of 100,000 men is reached.

The native troops are partly obtained by conscription and partly by enlistment. There are a few native officers, none of whom ever rise however above the rank of lieutenant and are, even then, always considered as junior to the white officers. The native N.C.O.'s are obtained on the same system as that in vogue in the French Army. A school for native N.C.O.'s was founded in Indo-China in 1906.

The length of the tour of foreign service of the white troops varies from 20 months to 3 years in the case of the officers, and from 20 months to 4 years in the case of the N.C.O.'s and men. The most peculiar characteristic of this force is its subjection to two masters, the War Office and the Colonial Office. It is believed that this will shortly be altered, although no one can say which of the two will be the ultimate head.

A further suggestion is that the Colonial and French Armies should intermingle more. The only practical solution to this at present seems to be to make the officers of both armies interchangeable, as such a step would greatly aid the difficulty in solving the *impasse* mentioned above.

The army of occupation in Northern Africa consists of the 19th Army Corps. Its strength is 75,000 men, far too great a number to be placed under the sole command of one army corps commander. It is suggested that this army corps should be divided into three, and thus its organization would be made more suitable for any oversea expeditions, or for the eventuality of portions of it being called upon to defend the mother country.

A last point is that which was brought before the public by Colonel Mangin in his book *La Force Noire*. In this he proposed that the colonies should be made to supply a greater proportion of levies than at present for their own defence, thereby releasing at least 30,000 French troops who would thus be able to fight in Europe. It remains as yet to be seen whether Colonel Mangin's ideas are practical or not; at the present moment there is an experimental body of natives of Senegal, part of which has been on service in Morocco, which as far as is known has proved a success.

A. H. SCOTT.

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Revue Militaire des Armées Étrangères.

June, 1911.

(1). The Austro-Hungarian Army at the Eve of Two Years' Service.—There is a great increase (500 million crowns) in the army and navy estimates of the Austro-Hungarian Empire for the year 1911 over those for 1910. Both the navy and army come under the same department (the War Department) and a large percentage of the increase is allotted to the navy. This is to be strengthened, both for the greater protection of the mercantile marine, which is daily increasing in importance, and for the protection of the coasts of the Adriatic. Thus in 1916, the strength of the Austro-Hungarian Navy will be:—13 battleships; 9 cruisers; 18 torpedo boat destroyers; 48 torpedo boats; and 12 submarines.

As regards the land forces, the estimates are less generous. Only 20 million crowns are allotted to them. The importance of this sum is, however, not so much its size as the purpose for which it is to be used, viz.:—The preparation of a military reform. The main details of this reform are:—The adoption of two years as the colour service for the infantry and artillery, and a considerable increase in peace establishments (from 103,100 to 159,000 men). As a corollary to this increase of the common army of both states, a proportional increase in the Landwehr of each nation is to be expected, amounting to 8,250 in the Austrian Army and 12,500 in the Hungarian Honved. This will bring the strengths of these bodies up to 28,000 and 25,000 respectively.

Before proceeding further it is necessary to explain the peculiar formations which exist in the Austrian Empire. Quite apart and distinct from the "Imperial and Royal" Army, which is common to both states, each country possesses a Landwehr formation, in which the time of service is 2 years with the colours, and 10 with the reserve. The origin of these bodies is the "Ausgleich" of 1867, which declared each state to be autonomous and gave it a parliament of its own. As a result the Austrian Landwehr and the Hungarian Honved sprang into existence.

The growth of the latter was more rapid than that of the former, and it rose in 1890 to its present strength of 12,500 men, *i.e.* 28 infantry regiments of 2 or 3 battalions each and 10 cavalry regiments, the only increase of late years being the addition of a machine-gun detachment to each infantry regiment and 2 detachments for the 10 cavalry regiments.

The Austrian Landwehr on the other hand, although it did not make at first such sudden strides as the Honved, is now the stronger of the two (19,750 men), and consists of 119 battalions each with a machine-gun detachment, 6 cavalry regiments, and 8 howitzer brigades. Five of the regiments were in 1909 and 1910 transformed into Alpine troops to supply a long-felt want. It will be noted that neither of these formations possess any engineers, departmental troops or artillery worth speaking of.

The present laws fix the length of service in the common army at three years with the colours, and seven with the reserve; the remainder of the soldier's service being spent in the Landwehr and Landsturm until, at the age of 42 he is exempt from all military duties.

The strength of the army has remained the same since its formation:

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viz.: 103,100 men. The reason for this stagnation is mainly to be found in the unwillingness of the Magyars to come forward and serve, and the support they get in this dilatoriness from their parliament. This results in their serving almost entirely in Hungarian regiments, attending Hungarian military educational establishments and using Hungarian as the official language in the corps they serve in.

The principal changes have taken place in the field and fortress artillery, those in the engineers being mainly the creation of cadre formations intended to expand largely in time of war. The arms which have suffered principally during this stagnation are the infantry and cavalry, especially the former, with the result that at the present moment, to mobilize a company of infantry it is necessary to call out lots of reservists of seven successive years.

In the matter of *matériel*, the army has made important progress, all the latest technical improvements, such as telephones, signalling equipment, wireless telegraphy stations, field cookers, mechanical transport, aeroplanes, or, in a word, anything demanding only expenditure of money, having been lavished on it. The navy has not, however, been forgotten, its strength being increased from the original 2,800 to 4,000 men.

The Bosnian crisis and subsequent partial mobilization in the winter of 1908—1909, showed up the defects of the present system, and both socially and economically disorganized the Empire. On the other hand it served to test the real unity which exists between the different races, and proved that all were willing to unite against a common foe.

Since this crisis two years have passed, and as yet no active steps have been taken to increase the peace footing of the common army. The present labour party in power, however, which succeeded the independent party, considers the question of imperial defence as one of the first importance and, it is more than likely therefore that the two years law will be passed.

Of the proposed increase of 55,000 men, only one-seventh will be allotted to new formations—mostly technical troops—the remainder will be employed in bringing the cavalry and infantry up to their proper establishment of 150 troopers per squadron and 93 men per company of infantry. In the words of the present War Minister, the object of the increase is not to attempt to catch up at one bound the enormous distance Austria lags behind the other Powers in things military, but merely to fill up holes in the present organization; in fact not to increase the army, but to consolidate it.

MILITARY NEWS OF DIVERS COUNTRIES:—

BELGIUM.—The Military School of Aviation has been opened at Brasschaet. Its staff consists of two lieutenants, one as technical instructor, and the other as practical instructor. The course is being followed by four subaltern officers. The aerodrome is some 2 kilometres long and 500 metres broad. The Belgian Government possess two biplanes (both Farman) and five hangars of which two are movable.

ITALY.—*The Duties of the Inspector-General of Engineers.*—The following come under this officer:—(1). The general officers attached to the

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inspection as inspectors. (2). Commanding officers of engineers as far as the training of the men, and the technical administration of commands is concerned. (3). The workshops of the engineers. (4). The troops allotted to the destruction of communications. (5). Military pigeons. (6). The historical museum of the engineers.

RUSSIA.—The results of the course held at the Military School of Aviation at Sebastopol, which ended in May, 1911, have been published. 23 officers have been trained (6 infantry, 1 gunner, 9 sappers, 4 cavalry and 3 naval officers)—of these 8 obtained a pilot's certificate (5 on Farman and 3 on Blériot machines). The following are the advantages granted by the Government to military aviators:—(1). An allowance of 1 rouble (two shillings) to every soldier for each day in which he takes part in a flight. (2). A monthly allowance for each month in which they have been for at least six hours in an airship to the following officers at the following rates:—"Captain" of the balloon, 150 roubles; his assistant or chief mechanic, 90 roubles; to each mechanic, 30 roubles. (3). A monthly allowance to the officers of the aviation sections of the balloon companies of 200 roubles per officer, 72 roubles per ensign for those months in which they have flown for at least six hours. (4). An annual allowance for the *personnel* of the above-mentioned sections who have served at least three years in them, and flown at least 50 hours per annum, of 300 roubles per officer, and 120 roubles per man. Once this allowance has been obtained, it is remitted to the individual even if he retires or is transferred to the reserve; in case of death it is given to his family over and above the ordinary pension to which they are entitled to. As regards pensions, any individual injured in a flight is entitled to the same pension as if wounded on service, the same applies if his health has been affected by flying and there are definite pensions which in the event of his demise are given to his next-of-kin.

The peace strength of the Russian Army in 1911 for fixed at 455,000 men, which is less by 1,535 men than the peace establishments for the years 1908, 1909, 1910.

TURKEY.—*Organization of the General Staff of the Ottoman Empire.*—The General Staff of the Ottoman Empire is divided into seven departments as follows:—(1). Manœuvres and training, military history, editing of the fortnightly military paper. (2). Study of foreign armies. Correspondence with military attachés. Officers sent to foreign countries. (3). Mobilization. Concentrations. Fortifications. (4). Movements and quarterings in peace. Correspondence with the Sublime Porte and The Vilayets.. (5). Military law. Organization. (6). A.A.G.'s department. Personal affairs of staff officers (appointment and disposal of officers). (7). Topographical department.

Ministerial Circular of December, 1910, on Staff Officers.—(1). A staff officer is only to be considered such when actually serving on the staff. (2). Officers who previous to the new regulations on the supply of officers for the General Staff have been given the rank of staff captains will have to be exercised in regimental duties and the handling of troops in the field. They will be considered as regimental officers of the arms they are attached or posted to. (3). Officers who have qualified for service

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on the General Staff will as required be employed on the staff once or more often, account being taken of the tasks referred to in para. 4. (4). In order to keep up the knowledge of officers qualified for service on the staff, but serving as regimental officers, tactical problems will be set them by the Chief of the General Staff, and marks allotted for their solutions of the same. These marks combined with the confidential reports rendered on them by the officers under whom they are serving will be taken into account when selecting these officers for staff work.

The N.C.O.'s of the Turkish Army.—N.C.O.'s are divided into extended and non-extended men, the former being those who continue in the army after their legal term of service is expired. The ranks are as follows:—Corporals (bachi), sergeants (tchaouch) and sergeant-majors (bach tchaouch). The N.C.O.'s are supplied as follows:—(1) From the N.C.O.'s schools, or (2) selected from the ranks, after passing an examination. The N.C.O.'s schools train young men of 18 to 21 years with a taste for soldiering. The course lasts two years and the successful candidates then come out with the rank of corporal. Preparatory schools for the N.C.O.'s schools also exist which prepare boys of 15 to 18 for the N.C.O.'s schools—the course lasts from one to three years according to the aptitude of the pupils. A school of each type is to be established at the headquarters of each military district, administered by a major or lieutenant-colonel in the case of the higher and a major or captain in the case of the lower schools. Pupils of the N.C.O.'s schools must serve at least six years, those of the preparatory schools at least eight from the time they leave the higher school. The sons of soldiers are admitted in preference to those of civilians. The pupils are paid by the government. After six years' service N.C.O.'s can extend for three years, the right to extend being a privilege granted to men of good record. At the end of this time they are ensured a post under the government outside the army.

A. H. SCOTT.

RIVISTA DI ARTIGLIERIA E GENIO.

May, 1911.

FRANCE.—*Technical Exercises for the Engineers.*—From the *France Militaire* of the 7th and 16th May, we learn that the annual exercises in navigation and bridging of the 3rd Regiment of Engineers have lately taken place near Estcourt-Saint-Quentin, 20 k.m. from Arras. Up to the 23rd April, all the necessary material, transported by water, had arrived at the station of Bequerel where the three battalions of the regiment were successively practised in the construction of several bridges.

Similar exercises for the 7th Regiment of Engineers were held at Besançon sur Doubs and were continued up to the 25th May, and other very important exercises in mining were carried out by the sappers of the engineers at the fort Montbérault at 8 k.m. from Laon.

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Aeronautics.—From the same journal of the 9th May, it is reported that 40 soldiers, carpenters by profession, were transferred to be employed in certain laboratories for the repairs to aeroplanes, and for similar duties 60 soldiers selected from the various arms and of the following professions, viz. cartwrights, carpenters, and aeroplane constructors, were transferred for practical experiments.

The experiments took place for 30 men at the aeronautical depôt at Versailles, and for the other 30 in the laboratories of the aeronautical depôt at the camp at Chalons. The first 20 classified in the examinations will be transferred to the 25th Battalion at Versailles, and to the detachment of aerostats at Reims. The others are remanded to their corps.

New Edition of Instructions for the Engineer Services.—The same Journal of the 11th May states that the 2nd edition of *Instructions for the Engineer Service* was published on the 1st February, 1911, and contains the general dispositions of the headquarter staff of the engineers, the classification of fortified places, and the service of the school of engineers, etc.

This new edition shows that the engineer arm is thoroughly fulfilling its new and important duties, has lost none of its prestige, and is always in touch with the daily life of the army. The price of this publication is 5 lire.

GERMANY.—*The New Instructions for the Use of Explosives.*—These instructions, which have been compiled under the care of the Inspector-General of Engineers, are intended to supersede those of 1903.

The rapid development of means of communication of every kind has conferred upon works of destruction a greatly increased importance. Further, the Siege of Port Arthur has brought prominently forward not only the employment of mines in siege warfare, but also the necessity of instruction in the use of explosives and mining work, and of adopting the best tools and material.

The new instructions contain a short introduction and eight chapters with the following titles:—(I.) General methods of demolitions by means of explosives. (II.) Explosives. (III.) Methods of ignition. (IV.) Demolitions. (V.) Mines. (VI.) Measures of precaution. (VII.) How to render ineffective explosives and ammunition. (VIII.) Composition and storage of material.

The instruction is chiefly intended for the pioneers, who are exercised in the use of explosives during the whole year, and for the battalions that have siege parks and are particularly exercised in mining warfare. A certain number of men in the other battalions who have special aptitude for the work are also instructed. Explosive 92 which is insoluble in water and is less sensible to mechanical action, is substituted for Explosive 88 now in use. It has the same properties as Explosive 88, but has the advantage of being usable in water, and of being contained in an impermeable covering.

A new electric apparatus for ignition has been adopted which is safer than that formerly in use.

Land mines (fougasses) are shown to be an effective means of defence

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when employed on a large scale; the instructions are illustrated with diagrams.

The necessity of rapidly constructing mining galleries of great length (100 to 200 m.) is recognized, as also the importance of well-conceived arrangements for aeration and illumination, and of thoroughly instructing the troops in this kind of work. The allotment of wires and firing apparatus of the pioneer companies is increased.

The new German instruction has been compiled to conform with the exigencies of modern warfare, and contains many technical lessons which are deserving of study.

Automobiles in the German Empire on the 1st January, 1911.—According to information taken from the *Revue Militaires des Armées Etrangères* of last May, the number of automobiles of every kind existing in the German Empire on the 1st January, 1911, is 57,805, showing an increase of 7,864 (of which 1,308 are heavy motor cars) since the 1st January, 1910.

The increase of heavy motor cars is thus distributed:—270 carriages of 8 H.P.; 387 of 8 to 16 H.P.; 627 of 16 to 40 H.P.; 99 of over 40 H.P. In motor cycles there is a diminution of 75. The increase of autocars above 16 H.P. (726 in 1911 and 319 in 1910) has a special importance from a military point of view.

1.—CARRIAGES FOR PASSENGERS.

	Motor Cycles.	Automobiles.				Total.
		Up to 8 H.P.	8 to 16 H.P.	16 to 40 H.P.	Over 40 H.P.	
Prussia	10,365	7,130	6,376	5,036	294	29,201
Bavaria	2,687	1,245	872	747	54	5,605
Saxony	2,442	1,543	902	712	27	5,626
Würtemberg	1,103	562	379	288	20	2,352
Baden	952	546	397	324	17	2,236
Other States	1,978	1,707	934	702	34	5,355
Alsace-Loraine	1,057	1,025	651	368	2	3,103
Total	20,584	13,758	10,511	8,177	448	53,478

2.—CARRIAGES FOR HEAVY TRAFFIC.

	Motor Cycles.	Automobiles.				Total.
		Up to 8 H.P.	8 to 16 H.P.	16 to 40 H.P.	Over 40 H.P.	
Prussia	54	1,026	519	791	71	2,461
Bavaria	20	229	188	173	15	625
Saxony	17	160	68	100	7	352
Würtemberg	4	53	69	93	12	231
Baden	1	39	37	53	12	142
Other States	22	148	84	122	11	387
Alsace-Loraine	3	40	34	52	—	129
Total	121	1,695	999	1,384	128	4,327

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THE CONCEALMENT OF FORTIFICATIONS.- By Lieut.-Colonel Maglietta, Engineers.—The art of concealing fortifications has long occupied the attention of the superior military authorities, and the method that generally has been specially recommended is that of planting trees around the works.

It cannot however be said that this important problem has been satisfactorily solved, or that everything possible has been done. The study of this subject has remained a dead letter, and its importance has not been sufficiently recognized either as a means of affording protection from the enemy, or as to expense—since a well-planned concealment of a fortification always corresponds to a reduction in the number of armoured and cemented works.

Trees have several disadvantages, as the cost of maintenance does not compensate for the small benefit that might be derived in a more economical way. Moreover the trees impede the view and this sometimes causes great inconvenience.

Without however entirely disregarding the theory of the trees, which in some cases may be desirable not as the chief means of concealment but as an auxiliary thereto, it is argued that the study of concealment should be specially treated in the preparation of plans for fortifications. The concealment should be such as to render it more difficult for the enemy to deduce the profiles of the works either from photographs or by means of spies.

It is generally accepted that, in order to be properly concealed, works should occupy as small a space as possible, and should also be as low as possible. Instead of this evident and indisputable proposition, we see works constructed which are ironically called low, but which have a command over the sea of 8 or 9 m.; we see towers or turrets for signalling or other purposes, raised to a height as much as 42 m. in the interior of a work, and along a line of rocks. The reasons given by the artillery for such a command is that, as the horizon increases 1 kilometre for each metre in height, they are able to see to throw their projectiles with greater effect.

The author does not believe that all this is necessary to make good firing practice. He advocates a system of batteries and emplacements concealed in caves, but the description is sometimes difficult to follow, and it would appear to be only applicable under certain conditions of the soil and contours of the ground.

E. T. THACKERAY.

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DRIFT OF A BULLET.

DEAR SIR,

May I suggest that Colonel de Villamil and Capt. Edgeworth expend a little further consideration on the following two points raised by them:—

(*a*). Whether the viscosity of the air is the only factor that can affect the rolling motion of a bullet.

(*b*). Why upward pressure should be applied to the nose of a bullet or gyroscope, when every known fact tends to show that the resultant force produces a downward movement of the nose.

I do not suggest that rolling motion is the only factor causing drift, but that up to date it is the only factor capable of logical and scientific explanation.

Yours faithfully,

A. B. CAREY,

Major, R.E.

The Editor, *R.E. Journal.*

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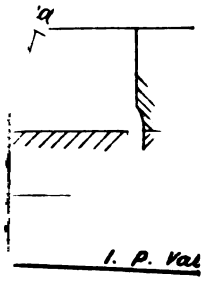

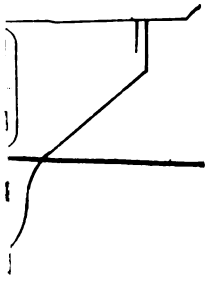

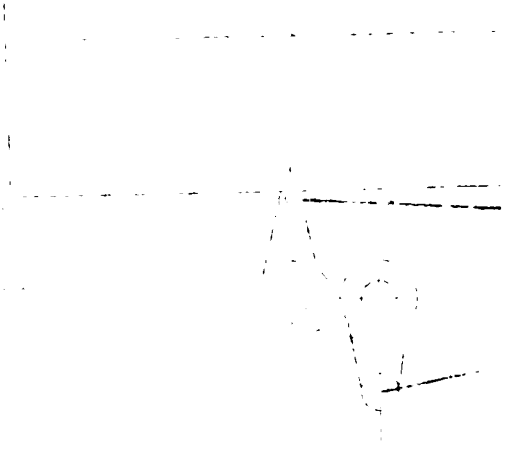

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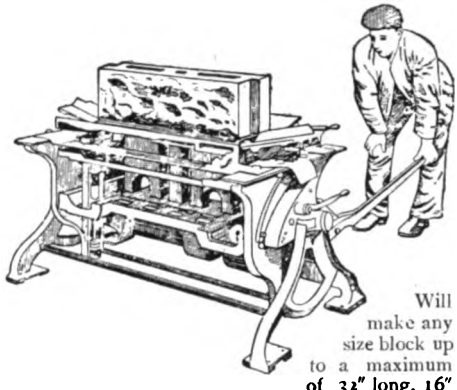

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,, Excess of Current Income over Expenditure ...	975 5 0			
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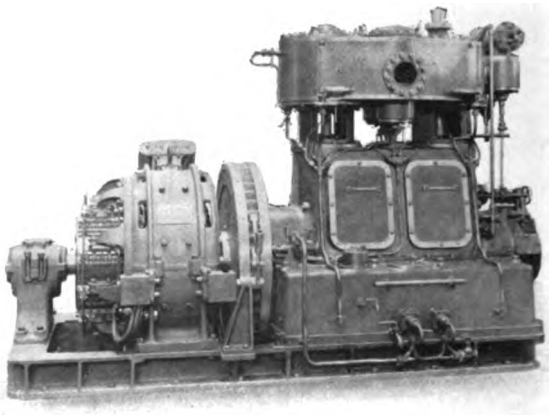

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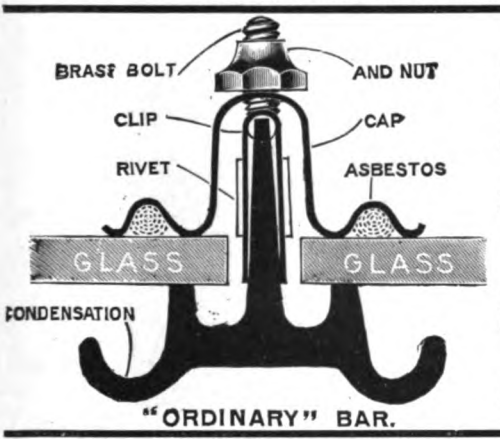

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GIRDER BRIDGES FOR MILITARY ENGINEERS.

(*Concluded*).

By Capt. E. N. Mozley, R.E.

PART III.

METHOD OF LAUNCHING RECOMMENDED FOR LARGE GIRDER BRIDGES.

(i.). Ideal Method.

The following description shows the ideal method of launching :— (In the 88′ span bridge (No. 6) under consideration Stage 1 was practically omitted ; Stage 2 was more difficult to execute than would usually be the case as the girder had to be rolled up a 1 in 20 incline (on two poles) so as to clear an old cantilever bridge anchorage. Stage 3 was carried out as described, Stages 4 and 5 were carried out as described but with only an 8′ command of sheers block over the far abutment and only one main tackle. Stage 2 and Stage 6 were executed generally as described but the small trestle referred to in Stage 6 was not placed on the cables).

The process may be divided into six stages.

Stage 1.—Carrying the girder bridge (two girders with all wind bracing on) from site of construction to position when front ends of lower flanges *just* overhang gap.

The girders should be 7′ centre to centre, say 8′ out to out. The bridge should be carried by spars underneath and at right angles to the lower flanges 6′ apart, *i.e.* 16 such spars for a 90′ bridge. If the bridge weighs 8,000 lbs. each spar will carry 500 lbs. If each man is to lift 60 lbs. 8 men should lift at each spar, 4 each side of the bridge. Allowing 8′ each side of the bridge for 4 men side by side the spars should be 24′ long. Five-inch diameter fir will be strong enough.

There may be 1 superintendent to every 8 men lifting, *i.e.* 16 superintendents and 128 men are needed to lift easily a 90′ bridge.

They should be practiced in walking with the bridge on the level and if necessary up and down hill before emerging from cover, to carry it to the gap.

In addition to the carriers there should be five side guys on each side of the bridge each manned by 2 men—20 men in all, to prevent the bridge tilting when being carried. These guys should be long in order to keep any lateral pull as horizontal as possible.

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With these arrangements the bridge should be carried at the rate of at least 6 yards a minute (allowing for frequent rests). It would probably be possible to increase this rate of advance to 10 yards a minute. In other words if the place of construction were anywhere within 300 yards of the gap and the approach were not too difficult the bridge could be brought up to the gap in half an hour.

Simultaneously with the emerging from cover of the carrying party the following parties would double out to the gap and carry out launching preparations :—

A. *Roller Party.*—30 men. Carry out four spars 30′ long and lay them as in *Fig.* 34.

These four spars should be picketed so as to prevent them shifting sideways, and should be supported by cross logs at the ends close to the gap.

The same party bring up the rollers of which there should be at least four, 18′ long and *not less* than 10″ diameter. Each roller to have a lashing made fast to each end so as to pull it back when it rolls into the gap.

The roller party will assist the anchorage parties when it has completed its work.

B & C. *Cable Parties.*—Two parties each of 20 men. They carry the cables forward, get them simultaneously across the gap and hand them to the cable anchorage parties.

D & E. *Near Side Cable Anchorage Parties.*—Two parties each of 6 men. They carry forward the pickets, log and mauls for making holdfasts for the near side ends of the cables and attach the cables to these holdfasts.

F & G. *Far Side Cable Anchorage Parties.*—Two parties each of 6 men. Duties as for D & E. They, with the assistance of the cable parties, haul the cables taut and take in the slack round the anchorages.

H. *Near Side Cable Abutment Party.*—6 men. They build up two low piers or abutments, if possible 3′ high, for the cables to pass over close to the brink of the gap on the near side. N.B.—If a 12″ spar is available to carry the front end of the bridge on the cables, the cables may be as much as 20′ apart.

K. *Far Side Cable Abutment Party.*—6 men, duties as for H.

L. *Far Side Cable Tackle Party.*—8 men (working in two parties). They carry across the two tackles (already rove) and pickets for two holdfasts for the tackles to pull the cables taut on the far bank. They drive in the pickets, affix the tackles and make the stoppers on the cables to which the tackles are attached.

M. *Far Side Sheers Party.*—20 men. They carry across the sheers (already made, with a cross piece lashed on and suspended from crutch), erect them, make fast the back struts and carry the back guy back to its anchorage.

N. *Sheers Back-Guy Anchorage Party.*—3 men. Place a holdfast for the back guy of the sheers.

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O & P.—*Far Side Main Tackle Parties.*—Two parties each of 8 men. They place holdfasts for the main runner tackles, which are attached to the guys which pass through the blocks on the sheers to the forward end of the bridge. They fix these tackle (already rove) and lead the guys (through the blocks if in place) to the near bank again, ready to attach to the bridge when required.

Q. *Side Guy Parties, Near Side.*—4 men, working in two parties. Drive a holdfast each side of the bridge, and make fast "preventers" to the top flange panel points where ordered, as soon as the bridge reaches the gap.

R. *Side Guy Parties, Far Side.*—4 men, working in two parties. Make holdfasts corresponding to those of Q, but on the far bank. The ends of the side guys to be led back across the gap to the near side ready to be attached when ordered.

S. *Rear Guy Party.*—4 men. They place a holdfast in centre line of bridge about 120′ from gap and attach a guy from it to the rear of the top flanges (with a bridle) as soon as the bridge is brought up. They also place two holdfasts (either side of the centre line and just clear of the bridge) to assist in tipping the bridge. These holdfasts to be a distance in rear of the gap equal to half the length of the bridge + 5′. This party also brings up a pole ready to make fast to these holdfasts and attaches two guys to this cross piece the other ends of which will be tied to the top flanges when the rear ends of these flanges are just over the holdfasts and the girder is about to tip.

T. *Excavation Party.*—3 men. They ramp off the near bank between the logs laid down by party A to allow the girder to tip on to the cables without catching the edge of the gap.

U & V. *Abutment Parties, Near Side.*—Two parties each of 4 men. Prepare the seatings for the ends of the top flanges on the near side.

W & X. *Abutment Parties, Far Side.*—Two parties each of 4 men. Carry out the same work for the far side.

All the above parties with the exception of M (sheers party) should, if they understand thoroughly beforehand what they have to do, complete their preparations in ¾ of an hour *if there is no great difficulty in getting men and stores across the gap.* If there is such difficulty, owing to precipitousness of sides of gap or rapidity of stream, a small party must be sent across previously and as secretly as possible to get a line across the gap, pull one cable across and then pass men and stores across on this cable by a carriage suspended from it.

Stage 2.—At the beginning of this stage the bridge is on the rollers with the forward end just overhanging the gap. If the necessary men have been available there will be on the near side 164 men in the carrying party, 30 in party A, 12 in parties D & E, 6 in party H, 16 in parties O & P, 8 in party Q & party S, 3 in party T, 8 in parties U & V, a total of 247: and on the far side 40 men in parties B & C, 12 in parties F & G, 6 in party K, 8 in party L, 20 in party M, 3 in

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party N, 4 in party R, 8 in parties W & X, a total of 101. The whole party is therefore 348 men.

Immediately the girder is set down upon the rollers the following will be carried out before launching :—

(1). A prearranged party will lash across and underneath the forward end of the lower flanges a stout pole (from 9″ to 12″, depending on weight of bridge and distance apart of cables) to convey the weight of the forward end of the bridge on to the cables when it is tipped.

(2). Parties O & P make fast their guys to this pole.

(3). Parties Q & R make fast their side guys and stand to their holdfasts to pay out or take in. Four men will be told off to assist them.

(4). Party S makes fast its rear guy and stands by the holdfast.

(5). Parties M & N continue erection of sheers.

(6). Parties B & F on one main tackle and C & G on the other main tackle prepare to pull the bridge forward.

Parties K, L, W, X on far bank are spare.

Men in pairs (each pair to one handspike) stand each side of the bridge to lever lower flange up if a roller sticks. Two men to be told off to each end of each roller to shift it when necessary. Remaining men on near side stand round outside of lower flanges prepared to shove forward.

When all parties are in position the word is given to launch forward. The bridge will be rolled forward on the rollers. As each roller reaches the forward end of its run it will fall into the gap and be pulled up by the lashing made fast to it and if necessary placed under the bridge in rear.

The main tackle parties on the far side will assist, and the bridge will be pulled forward till it is approximately balanced on the forward roller which should then be within 1′ or 2′ of the gap.

It should be observed that the number of men here employed are by no means necessary for the actual launching of the bridge. As a matter of fact a 90′ girder bridge for infantry two deep can be lifted and carried by 100 men, and can be rolled forward and pulled over the gap by 60 men. The large numbers here given are with a view to *simultaneous* and quick execution of the preparations for launching. It will generally be sufficient to have, say, 150 men to carry the bridge to the gap and 100 to launch it, (60 men on the near and 40 on the far bank).

Stage 3.—*The cables having been pulled up as taut as possible so that the "stretch" is taken out of them,* the bridge is tipped up and the forward end allowed to drop down on the cables as follows (*Fig.* 33) :—

As soon as the bridge is so far forward that it is balanced about the forward roller remove all other rollers except one. Place this one about 5′ behind the one on which the bridge is balanced.. Now bear

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down on the rear end of the bridge, taking in the slack of the vertical lashings made fast between the rear ends of the upper flanges and the pole brought up by party S, which is now lashed to its holdfasts. The front half of the bridge will now rise and the bridge itself will pivot about the rearmost of the two rollers and the other can be removed. Now slack off the rear vertical lashings and the forward end of the bridge will sink on to the cables.

This is a better method than at once tipping the bridge about the foremost roller, as it saves the rear end of the girders from going too high in the air and the tipping is more under control. The whole of this process will not take more than five minutes.

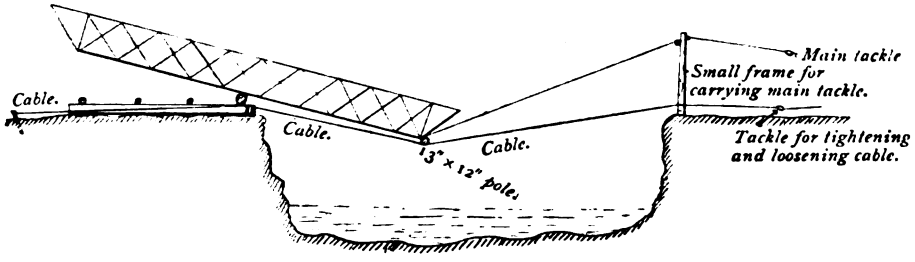

FIG. 33.

Stage 4.—The pulling and rolling forward of the girders is continued and, since the centre of gravity is now descending, the pull will not be a hard one. The cables should have been greased in front of the pole which slides on them.

As soon as ever the sheers are ready, the two forward guys should be lifted up and slipped into the snatch blocks hanging from the cross-piece. This will give somewhat of an upward pull on the front of the girder and prevent excessive sag of the cables. The rear half of the girder moves forward on one roller which is followed up, at not more than 2′ or 3′ interval by another one, so that, when the foremost one falls into the gap, the drop of the bridge on to the one behind will be very small.

This stage, during which the forward end descends, will continue till the forward ends of the lower flanges are about two-thirds of the way across the gap. Then the upward pull from the snatch blocks on the sheers will be sufficient to begin to lift the front of the girders. It will be necessary once or twice to overhaul the main tackles (which should always be overhauled *together* to save time). The slack of the guys attached to these tackles should be taken in where they are attached to the girders and not at the tackle.

During these processes of overhauling the following operations should be performed :—

(*a*). A spar should be *lashed* underneath the rear ends of the lower flanges.

(*b*). A small trestle or crib, previously put together, should be

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placed across the cables about 5′ from the near abutment to break the fall of the girders when the rear ends of the lower flanges slip off the abutment. This trestle should have foot-ropes to it secured to holdfasts on the near bank, by means of which it can be allowed to slide down the cables if necessary.

(*c*). The two poles, AB and CD in *Fig.* 34, should be roughly framed together with lashed spars and nailed planks, as shown in dotted lines, so as to enable them to be worked together as a single lever in Stage 6.

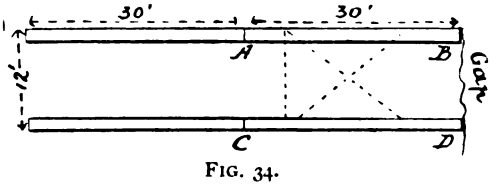

FIG. 34.

Stage 5.—This is merely a continuation of the preceding stage, and only differs from it in the fact that the forward ends of the girders will now begin to rise towards their abutments. As soon as the rear ends of the lower flanges are within 3′ of the near abutment the bridge will be allowed to take its bearing on to the roller which has been lashed to them. The side guys on the far bank may be used to assist in the forward pull.

Stage 6.—As soon as the spar lashed to the rear of the lower flanges comes vertically over the ends of the logs on which it *slides* (*i.e.* over the edge of the gap) the rear end of the bridge must be lowered on to the cables. This is done as follows :—The rear end of the bridge is lifted up a few inches with levers so that the two poles AB and CD on which the lashed roller rests can be slid forward over the gap about 4′. The bridge is then pulled forward again 2′ or 3′ while men bear down on the inshore ends of these poles to prevent them tipping. As soon as the lashed roller is sufficiently far out the poles are allowed gradually to tip up and the rear of the bridge will be lowered on to the cables. Any sudden slip will be caught by the small trestle which has been placed across the cables close to the abutment for this purpose.

As soon as the weight of the lashed roller is brought upon the cables the bridge is again pulled forward till the ends of the top flanges are over their seatings. The tackles attached to the cables on the far side will now be paid out and the cables themselves paid out at the anchorages. The bridge will then be gradually lowered till the four ends of the top flanges rest on the seatings prepared for them.

During this final stage all the side guys must be double-manned as any sudden slip of one lower flange, or extra stretch of one cable will cause the bridge to tilt, which must be at once met by a slackening out of the other cable to bring the bridge level again.

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It is for this reason that the cables should be as wide apart as the strength of the rollers and poles will allow, since any difference of level of the cables will have a tilting effect inversely proportional to the distance apart of the cables.

It is necessary to note that, while the sheers will probably lean forward towards the gap when first the tackles are passed through the snatch blocks on its cross-piece, it will subsequently tend more and more to lean backwards, since the resultant downwards pressure of the two parts of the guys will make an increasing angle with the vertical towards the rear. For this reason the back struts must be lashed high up the sheers and must have good footings.

Throughout the operations whistles should be carried by the following :—

1. The officer in charge of operations who will find it best to stand close to the gap on the near side.

2. An officer stationed between the abutments on the far side to judge as to (*a*) correct direction, (*b*) any tilting of the bridge, (*c*) when the main tackles require overhauling.

3. An officer or N.C.O. in rear of the bridge to judge as to any necessity for a cross-lift to the rear of the bridge, either to correct any deviation of direction or to place correctly any roller which may have got askew.

The stopper hitches for the tackles to the main cables on the far bank must be exceedingly well made, as any slip on their part may give the bridge a dangerous tilt.

The cables should not sag, at the most, more than 8′, and the maximum will be reached just before the lift from the sheers is felt (at the end of Stage 4).

There should be plenty of packing and wedges of various sizes laid along each side of the bridge on the near bank ready for use as fulcrums, etc.

It is of little use to place cross-pieces on the cable or on the underside of the lower flanges anywhere except near the abutments, as in any other positions such cross-pieces will fail to convey weight to the cables.

If insufficient men are available on the far bank, secondary runner tackles can be fixed to the running ends of the main runner tackles. By such means eight men have pulled an 8,000-lbs. bridge across a portion of a 90′ gap at the rate of 1′ in three minutes.

The snatch blocks from the sheers should hang 12′ above the abutments, but the bridge *can* be pulled up on to its seatings on the far bank, if sufficient tackle and men are available, with the snatch blocks only 5′ above the abutments.

In the scheme worked out above, two main tackles to the forward end of the bridge have been arranged for. One is, however, quite capable of doing the work though at a somewhat reduced rate.

In the final stage, when the poles, on which the spar lashed to the

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rear of the lower flange slides, are used as levers it is important that they should be tipped *together*, so that one side of the bridge will not tip before the other. For this reason they should be framed together as suggested. Their ends should *not* be greased.

The girder seatings prepared by the parties U, V, on the near bank should be kept as low as possible to prevent them fouling the end of the bridge as it drops on the cables.

The operation of paying out the cables in the last stage to let the bridge down on to its seatings is very quick and effective. The anchorages must be so arranged that the slack can be immediately paid out.

In order to prevent (*a*) braces or web planks protruding below lower flanges, (*b*) lower flanges being injured by the levers, the lower flanges should not, if it can be helped, be less than 7″ or 8″ deep, and, if they have cover plates on the underside, such cover plates should be continuous from end to end of the flanges. Bolts passing vertically through the lower flanges should have their heads downwards.

Rollers must be long enough. The distance between the spars on which they roll should be half as much again as the central interval between the girders, and the rollers should overlap each spar by 3′.

Rollers should be kept greased.

Levers *must* be long. 6′ handspikes are little good. 12′ hardwood levers are needed.

Light lines should be stretched across the gap by which stores, side guys, etc., can be hauled to and fro, without having to send men across.

(ii.). REMARKS ON THE ACTUAL LAUNCHING OF THE 88′ BRIDGE (NO. 6) UNDER CONSIDERATION, WITH NOTES ON THE TIME TAKEN.

In order to surmount a local obstacle the bridge had to be rolled up a pair of 55′ poles, laid at a slope upwards to the gap of 1 in 20, and supported at intervals by packing. There was moreover a large tree at the edge of the gap close to the centre line of the bridge, whose branches interfered considerably with the operation. In addition to this the rollers were only 7′ long and therefore kept tending to roll off the poles, and had to be constantly shifted. The tail of the girder also had to be frequently lifted round into the correct alignment. The slope up which the bridge was pulled took it 2′ or 3′ off the ground, where it was more difficult to handle, and the incline greatly retarded the speed of the operation. If these difficulties, which were abnormal, had been absent the process of launching would have been much easier.

107 minutes was taken over Stages 1 and 2 during which the front of the bridge was moved forward from 60′ behind the edge of the gap to 32′ beyond it, when the tipping process (Stage 3) began. Of this

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time 66 minutes were occupied in changing rollers and shifting the tail of the girder into the centre line, 18 minutes were occupied in adjusting tackles and placing the front spar, and 23 minutes in actually rolling the bridge forward uphill for 92′.

Stage 3 was carried out, exactly as described, in 5 minutes.

Stage 4, during which the front edge of the bridge advanced from 32′ to 56′ beyond the edge of the gap, occupied 50 minutes; of this 30 minutes was taken up in shifting the tail of the girder into the centre line (the deviation being chiefly due to the shortness of the rollers), and 20 minutes in actually advancing the bridge 24′.

Stage 5, during which the bridge moved forward 18′ till the front end was 14′ from the far abutment occupied 38 minutes, including overhauling the tackle. Ten minutes would have been saved if the rollers had been long enough.

Stage 6, including the remainder of the advance and the lowering of the tail of the bridge till the upper flanges rested on the abutments, took 35 minutes. The arrangements for the lowering were not as perfect as in the scheme which has here been sketched out, and one side of the tail slipped down more quickly than the other; 15 minutes were taken to rectify this.

The actual time therefore, compared with the time which would have been taken if the locality had been favourable and the stores adequate, may be stated as follows:—

Stage.	Advance of Girder in Feet.	Actual Time (Minutes).	Time, if Abnormal Difficulties had been Eliminated.
2	92	107	41
3	—	5	5
4	24	50	20
5	18	38	28
6	14	35	20
Total ...	148	235	114

Four hours may therefore be considered the maximum and two hours the minimum time for Stages 2 to 6 of a bridge of this size. With practice two hours should be sufficient on a favourable site.

To add the time for the other stages, from the time of emerging from concealment to the time the roadway is completed:—

With sufficient men, good organization and fairly favourable ground

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Stage 1 (carrying from cover to the gap) should not exceed 30 minutes.* Placing the roadway in the method described, 30 minutes. Therefore the total time of exposure to the enemy would be three hours.

(iii.). STRETCH OF CABLES.

In launching an 8,000-lb. girder bridge it is probable that at no time is the load on the two cables together greater than 5,000 lbs., and this will be about when the bridge is two-thirds of the way across. If 3″ wire cables are used they should not sag more than 7′ or 8′ (less, if the stretch is taken out of them by the tackle before they are loaded). If only 2″ wire cables (breaking stress, say 9 tons) are available, the cables will be safe with a sag of 11′ or 12′, but the lift in the penultimate stage will be heavy if the sag is so great that it exceeds the depth of the girder.

PART IV.

TIME NECESSARY TO MAKE AND JOIN TOGETHER TWO GIRDERS.

As a comparison between the time taken to build nailed girders and bolted girders respectively the following figures are given :—

A 78′ girder bridge for cavalry in single file put together with nails took 296 M.H. (cadet labour). An 88′ similar bridge but put together with bolts and nuts took 369 M.H.†

(If the former bridge had been 88′ long it would properly have taken $\frac{88}{78} \times 296 = 333$ M.H. and if this is so, a nailed girder appears to be rather quicker to build than a bolted girder. It also undoubtedly takes less skilled labour and less accuracy).

If sapper labour were available and if the men had been trained to the work and if nails were used it is probable that a 90′ bridge could be put together in 180 M.H. *i.e.* at 2 M.H. per foot of span.

Not more than 10 men at one time can be economically employed in building the girders. 30 men can lift or turn them. Therefore the least time in which a 90′ girder bridge can be built (exclusive of launching) is probably 18 hours, or including launching and laying the roadway 21 hours, of which only the last three need be under the observation of a possible enemy.

* The following are the results of experiments :—

90 cadets, with difficulty, carried the bridge in the direction of its lengths at 3 yards a minute. The rate was retarded as the lift had to be taken at the lower flanges instead of at cross-pieces under them. The rate could be doubled or trebled with 150 practised men, lifting at cross-pieces.

The bridge can be *rolled* forward on level ground, if nothing such as the lower ends of braces interferes with the rollers, at 6 yards a minute. Allowing for stops for adjustment of rollers, etc., it would be safe to reckon on 3 yards a minute. Of course fewer men are needed.

If the rolling has to take place up a grade of 1 in 20 a rate of 1 yard a minute can be maintained.

† $\frac{1}{3}$ time to build the flanges.
$\frac{1}{3}$,, ,, brace flanges together.
$\frac{1}{3}$,, ,, erect into vertical planes and cross brace together.

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Bridge number ...	1.	2 (i.).	2 (ii.).	3 (i.) (ii.).	4.	5.	6.
1. Date of erection	1899.	1901.	1901.	1904.	1904.	1906.	1908.
2. Place of erection	Christchurch.	Chatham.	Chatham.	Herne, Christchurch.	Christchurch.	Kingston, Canada.	Kingston, Canada.
3. Span in feet ..	51.	36.	42.	49.	57.	78.	88.
4. To carry	Cavalry single file.	Infantry in fours.	Infantry in fours.	Cavalry single file.	Cavalry single file.	Cavalry single file.	Cavalry single file.
5. Type of girder ..	Fished beam.	Inverted bowstring.	Inverted queen post.	(i.) Warren, (ii.) Plate.	Warren.	Plate (triangular section).	Single lattice.
6. Reference to Fig. or photograph.	*Fig.* 5.	*Fig.* 6.	*Figs.* 7, 8, 9.	*Figs.* 10 to 15.	*Figs.* 16 to 22.	*Figs.* 24 to 29 and *Fig.* 3.	*Figs.* 30 to 33 and *Fig.* 4.
7. Roadway carried on.	Upper flanges.	Upper flanges.	Upper flanges.	Lower flanges.	Upper flanges.	Upper flanges.	Upper flanges.
8. Distance between girders, centre to centre.	6′.	10′.	9′.	9′ 6″.	7′.	4′ 6″ (top flanges).	7′ 4″.
9. Depth between flanges, centre to centre.	2′ at centre.	5′ at centre.	7′ 6″.	(i.) 6′, (ii.) 6′.	5′ 6″.	6′.	7′ 4″.
10. Dimensions of one upper flange.	*8″ spar.	7 12″ × ¾″ planks.	2 pieces 12″ × 6″.	(i.) 4 planks 6″ × 2″. (ii.) See *Fig.*	*8″ telegraph pole.	*8″ spars.	5″ × 5″.
11. Dimensions of one lower flange.	Composite wire.	8 do.	1½″ chain.	(i.) 2 planks 6″ × 1″. (ii.) See *Fig.*	Composite wire.	*10″ spars.	5″ × 5″.
12. Dimensions of web.	See *Fig.*	2″ planking.	See *Fig.*	(i.) 6″ × 1″ planks. For No. in each brace see *Fig.* 10. (ii.) ½″ planks (see *Fig.*) and stiffener.	8″ telegraph poles and composite telegraph wire.	2″ and 1″ double planking (see *Fig.*) and stiffeners.	Assorted planking (5″ × 3″ to 3″ × 1″).
13. Method of transferring tensional stress at joints in lower flange.	—	Planks nailed to each other and breaking joint.	—	(i) Dowelled or bolted cover plates. (ii.) Nailed cover plates.	Wires passed through auger holes in feet of compression braces.	Wires passed through auger holes in spars of lower flange.	Cover plates bolted through scantlings of flange.
14. Fastenings employed between flanges and web.	Trenails and lashings (see *Fig.*).	Wire nails and ½″ bolts.	Dogs and spikes (see *Fig.*).	(i.) 1⅜″ dowels or 1″ bolts. (ii.) 2½″ cut nails.	See *Figs.* 17—19 for upper flange joints.	6″ wire nails.	1″ to ⅜″ bolts.
15. Bracing between girders (in addition to road transoms).	2 lower cross-pieces.	1 cross-piece at centre of bottom flanges and 2 diagonal braces.	See *Fig.*	Exterior sloping struts fixed to extensions of road transoms	Wind bracing between top flanges, and cross diagonals of wire between girders.	Wind bracing between upper flanges (see *Fig.*).	Wind bracing between top flanges and between bottom flanges, and cross diagonal braces.

* Central.

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16. Weight of both girders and bracing (lbs.).	Not estimated.	About 4,000.	About 4,500.	(i.) 1,400. (ii.) 1,600.	5,000.	8,000.	8,500.
17. Method of launching.	Girders singly with 15′ sheers on far bank.	30′ sheers on each bank. Girders slung out singly.	As for 2 (i.), but girder launched in one piece.	20′ frame on far bank and rollers.	2 20′ frames, girders launched together.	60′ derrick on far bank, 35′ frame on near bank, rollers & tackle from far bank.	Slid out on rollers and suspension cables; pulled across with tackle from 8′ sheers on far bank.
18. Remarks on launching.	Girders should have been *first* braced and *then* launched together.	As for No. 1. This bridge had 2 spans.	This girder was built and launched upside down, and turned over in the air, a difficult process.	Worked well.	Shallowness of gap impeded operations.	Derrick and frame took too long to erect. Great local difficulty on near bank. Girder had to be launched upside down, which involves turning in the air.	Very successful, but could be further improved.
19. Time in hours of:—							
(*a*). Construction of girders.	13.	29.	13.	50.	21½.	30.	37.
(*b*). Launching of girders.		6.	4.	1.	3.	8½ (longer than usual owing to site).	4 (longer than usual owing to site).
20. Working party for 19 (*a*).	2 R.E.	6 R.E.	16 R.E.	6 R.E.	16 R.E.	10 } cadets.	10 cadets.
Ditto 19 (*b*)	14 cavalry.	40 R.E.	40 R.E.	50 R.E. and cavalry.	50 R.E. and cavalry.	60 }	50 to 70 cadets.
21. Total men-hrs. to make the bridge.	208.	414.	368.	350.	492.	823 + 147 for derrick + 50 for frame (see note to 19*b*).	609 (see note to 19*b*).
22. Test	None.	See *Photo.*	See *Photo.*	(*a*) 50 cwt. dead. (*b*) 32 ,, live.	Equivalent to maximum load, slight failure.	4,200lbs. live load, marking time at centre of bridge.	See *Fig.* 23.
23. Observed deflection during test.	—	—	—	Very small.	4″.	3½″. Reverted to 2″ when load was removed.	See *Fig.* 23.
24. Oscillation	—	Very little; none after bracing between girders was put on.	None.	Very little.	Not fully observed.	Some, chiefly due to *single* lower flange.	Very little.

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HISTORICAL DOCUMENTS OF MAJOR-GENERAL SIR J. T. JONES, BART., K.C.B., R.E.

A NUMBER of most interesting and valuable papers and MSS. which originally belonged to Major-General Sir John Jones, have recently been kindly presented to the R.E. Museum by his grandson, Sir Lawrence Jones.

As A.D.C. to General Leith, Sir John took part in the retreat to Corunna in 1808-9. In 1809-10 he was in charge of the construction of the lines to cover Lisbon, and later on, as Brigade Major of Engineers, took part in most of the Sieges in the Peninsula. He was severely wounded at the Siege of Burgos in 1812, being incapacitated for the next two years during which time he published his *Journal of Sieges of Spain*. Some years later he compiled a short history of the Peninsular War, and in order that his details should be correct he obtained from many of the generals, who took part in the Campaign, notes and criticisms of the work done by the Divisions, etc., under their command.

The papers presented to the Museum not only include some of the Duke of Wellington's original orders and instructions, but also the whole of Sir R. Fletcher's correspondence on Torres Vedras, memoranda by Sir A. Dickson on the artillery preparation for the sieges of Ciudad Rodrigo and Badajos, and MS. accounts by Sir H. Clinton, Sir C. Colvile and other generals of the work done by their Divisions in some of the principal battles. There are also numerous letters from R.E. officers describing the different battles in which they took part.

Although Sir J. T. Jones has already published the whole of the Torres Vedras correspondence as an Appendix to his *Lines to Cover Lisbon in 1810*, many of the other documents do not seem to have been made use of, and, as they are of considerable historical and Corps interest, it is now proposed to reproduce some of them in the *R.E. Journal*. Practically all of the Manuscripts are in connection with the Peninsular War, and the three published in the present *Journal* refer to the year 1809. The two first letters deal with the rout and destruction of General Loison's Column at the Battle of Vimiera—an incident incorrectly reported in Lord Wellington's despatch. The third document is partly in the handwriting of Sir R. Fletcher and partly in that of Sir S. R. Chapman, and is a copy of Lord Wellington's original memo. and orders for the construction of the Lines of Torres Vedras.

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(1). *Copy of a Letter and Memoir from Major-General Sir G. T. Walker to Sir J. Sinclair, Bt.*

HARLEY STREET, *August 4th*, 1816.

DEAR SIR,

Although I had no desire to take advantage of your offer to give publicity to a narrative, now become by subsequent events of little comparative importance, I was yet in hopes for your personal satisfaction to have been enabled earlier than this to furnish you with such explanations as might assist you to comprehend a subject which you have deemed worthy your attention * * * *. But indeed on reference to the Narrative* I inclosed to you, I still feel a difficulty in giving any further details than I have there already done, as to "the Manœuvre practised in the defeat of the French Column at Vimeira." It is there stated that on the near approach of the Enemys Column my Regiment (then formed in line) commenced the attack by a movement to the left in Echellon of Companies of the right wing, while the left occupying a space nearly equal to the front of the Enemy's Column, stood fast. It was then meant on re-forming the Right Wing into a line oblique to the Enemys flank, to charge that, and his front at the same time; but finding that the advance of his Column was becoming too rapid to admit of the delay which this would occasion, I found it necessary as soon as the two left Companies only were formed, to order a Volley and charge of the whole, (the 3 other Companies of the right wing still in Echellon) which, notwithstanding the fire of the Enemy was as great as a close Column so formed could produce, completely effected that route and confusion, consequent upon such a formation when attacked in flank, or rear while its front is occupied. The truth is that the attack in close Column was an invention of the French Revolution, to bring forward undisciplined Troops, against those supposed to be disciplined, and unfortunately however skilled these may have been in tactics and practised in the old and slow forms of discipline, deprived as they were by a long peace of its superintending and pervading spirit, the presence of mind, the quick eye, the prompt decision of the Officer used to Combats, and inspired by a vain confidence built on the recollection only of the skill and success of their fathers, which only served to place them in the way of destruction—astonished and terrified at the unwonted attacks of these enormous masses, it was not unnatural that such Troops should be overwhelmed by them. Bonaparte readily adopted a system suited to the savage character of the Monster, prodigal of blood and with numbers ever at command, in his successive Columns of attack, he

* The one I sent to you being Copy of that on which was grounded the grant made by the Sovereign of the word *Vimeira* as an honorable Badge in the Colours of the 50th Regt.

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freely expended the product of his horrid conscriptions, careless of the amount, provided Victory was the purchase, and altho' hardly earned experience began to oppose to him some expedients, the rapidity peculiar to this Man and which characterised all his movements, the horrid and wide wasting destruction all his Armies carried with them, thro' a long unbroken chain of success, added to the want of union and decision in his opponents, occasioned the French Armies to be viewed only through a medium of terror, their progress to be considered irresistible and their tactics perfect. In such a state of things the example set at Vimeira was of an importance that ought not to have been obscured by the Cloud which public opinion drew down upon the subsequent Convention.

It was here that for the first time, beaten and routed, this invincible Column *en masse* fled, and like a flock of sheep, before a British force, not a fifth of its numbers, nor even more has the charm first broken at Vimeira since availed against coolness and discipline. As to giving however any further details of the attack and defence on that occasion as offering a system generally applicable, which appears to be the object of your request, I fear this explanation will have afforded you but little satisfaction. To a Military Man it would be unnecessary to add that such defences must be determined by local circumstances, for although an Echellon on that occasion was employed, and is I believe generally speaking one of the safest and most expeditious manœuvres under fire, various others might under other circumstances become more properly applicable—the object being by an attack on its flank or rear to create alarm in a mass, the greater part of whose members are incapable of being brought into action and where confusion once prevailing neither the judgment or courage of Officer or Soldier can avail ought, the whole being crowded off together. With disciplined Troops then to oppose to it, possessing but due confidence in their Commander, and with coolness, judgment, and decision in the latter it must ever be desirable that our Enemy may persevere in this system of attack.

I have the honor to be, &c.,

(Signed) G. T. WALKER.

SIR JOHN SINCLAIR, BT.

Memoir of that part of the Action of Vimeira Augt. 21st, 1808, in which the 50th Regt. was more particularly engaged.

In Sir Arthur Wellesleys Dispatch where the Position of the Army previous to the Action of the 21st August is described, it may be observed that "General Fane occupied a Hill in front of the whole with the 50th Regt. and his Riflemen." The latter then consisted of

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4 Companies of the 95th Regt. and a Battn. of the 60th—this Battalion however when the left of the Line advanced was ordered away for its support and three Companies out of four of the 95th being then employed on Picket or sent to its support in the wood in its front (then attacked by Kellerman's division). The 50th Regt. with a *Single* Company of the 95th were left alone to defend the Hill, supported however by 3 Guns under the immediate direction of Lt.-Col. Robe, R.A., for though (B.-Genl. Anstruther's Brigade having been posted during the night behind the Hill in rear of the right of this Position) the 97th (one of his Regts.) had (as was afterwards learnt) received orders to advance and take up the alignement vacated by the 60th, this movement was not actually executed till some time after the 50th was engaged. The Enemys attack having commenced by an endeavor to force the Pickets in front, B.-Genl. Fane permitted Col. Walker to take two of his Companies to support that of the 50th together with which they were afterwards obliged to retire to a rising ground a little advanced from the left of the Position, where the excellent and incessant fire from this Detachment, contributed in the sequel very materially to the success of the action by attracting the attention of the Enemy to that Flank during the manœuvre performed on the right. In consequence of the absence of these Companies, the others of the left wing were necessarily extended with intervals on the most commanding ground, so as to cover the passage to the Town. Thus situated a massive Column of the Enemy composed of 5 Regts. in close order of half Battns. supported by 7 Pieces of Cannon and under the Command of the General of Division Loison was making a rapid march towards the Hill, and though much shaken by the steady fire of the Artillery, after a short pause behind a height to recover, again continued its advance till Lt.-Col. Robe no longer able to use his Guns, considered them as lost. Till this time the 50th had remained at ordered Arms, but as it was impossible on the ground on which it stood, to contend against so very superior a force, and Col. Walker having observed the Enemy's Column to incline towards the left, proposed to B.-Genl. Fane to attempt turning its Flank by a wheel of the right wing. Permission for this being obtained, the Wing was immediately thrown into Echellon of Companies of about 4 Paces to the left, thus advanced for a short distance, and then ordered to form Line on its left. The rapidity however of the Enemys advance and their having already opened a confused, though very hot fire from the flank of their Column, although only two Companies of the Wing were yet formed, these were so nearly in contact with and bearing upon the Angle of the Column that Col. Walker, thinking no time was to be lost, ordered an immediate Volley and Charge. The result exceeded his most sanguine expectations—the Angle was instantly broken, the Drivers of 3 Guns advanced in front, alarmed at the fire in their rear, cut the

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Traces of their Horses and rushing back with them, carried additional confusion among the Enemy, which, by the time the 3 center Companies could arrive to take part in the charge, became general when this immense mass so threatening in its approach but a few minutes before, became in an instant an ungovernable Mob, carrying off its Officers and flying like a flock of sheep almost without resistance, for upwards of two Miles, when on clearing a Wood, Col. Walker observing a body of Cavalry drawn up in a small plain and threatening his flank, deemed it prudent to put a stop to the pursuit, as a party of the 20th Dragoons, which had previously joined in it, had already, by getting entangled in a Wood, suffered too seriously to be capable of affording any further assistance. Having from hence reported his situation and received B.-Genl. Fanes orders, Col. Walker retired with the Regt. to its former position, while the Enemy continued their retreat Eastward in a direction different from their resources.

Strength Embarked ...	3947
Killed	1000
Prisoners	360
Engaged	5307

Exclusive of 1,071 (according to the French Embarkation Return) of sick in Hospital, of Artillery Men and of Officers.

The immediate result of this success of the 50th, including the assistance derived from the Artillery during the advance of the Enemy, and from the 20th Dragoons in their retreat was 1000 Killed, 360 Prisoners and 6 Pieces of Cannon—the Regt. not mustering at the time 900 Men in the Field, the Enemys Column upwards of 5000. Genl. Anstruther's Brigade on the right having been too fully occupied with the attack of Kellerman's reserve to be able to take any steps whatever in the immediate support of the 50th and that it may not be imagined the numbers of the Enemy are here merely stated at hazard, a Copy* of the order of Battle found on a French Colonel killed in action, countersigned by Charlot one of the Brigadiers of this Division, and afterwards acknowledged by him personally, will accompany this Statement, on which it is only necessary to remark, that from his information, and that of General Loison, the subsequent change of Regts. mentioned in the Margin took place early in the morning of the Action. When this Paper is compared with the Embarkation Return† of the Enemy, given in after the Convention, where independant of the Sick in Hospital among which must have been *many* wounded and after all the loss of killed and Prisoners, the strength of the Regts. engaged under Loison remained at 3,947, their numbers in action cannot be said to have been over-rated.

Sir Arthur Wellesley having been occupied with the left Wing of the

* The original of this has been since lost in the plunder of M.G. Sir G. W.'s baggage at Badajos; but a Copy with the changes therein is still in his possession and another original order in the possession of Genl. Fane.

† To be found in the Office of the Secretary of State with the Signature of the Chief of the French Staff. Original Copy lost also at Badajos.

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Army during this operation, and separated by a Ravine and woods from the position of the 50th, was not made acquainted with the particulars here detailed at the time his Dispatches were written, having then only learnt generally what he therein states, "that the Enemy were checked and driven back only by the Bayonets of that Corps" but having afterwards heard the whole from General Loison himself (who particularly requested to be made acquainted with Col. Walker) he did him the honor to send for him and express his regret at not having received earlier information, but assured him that he would not fail to make His M. Ministers fully acquainted with the facts; which he afterwards learnt from Lord Castlereagh had been done. The circumstances however though never officially before the public, are so well known to the whole of the Army that full proof of the correctness of this narrative must at all times be easy. M.-Genl. Fane however who then Commanded the advanced Guard is still in England. This Officer saw the whole and can be confidently referred to, or should more be required there can be no difficulty in referring to Marquis Wellington himself where confirmation is certain.

(Signed) G. T. WALKER,
M.-Genl.

WINDSOR, *October 17th*, 1812.

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(2). *Letter from Lieut.-Colonel W. Robe, R.A., to Sir J. T. Jones.*

SHOOTER'S HILL, 18 *June*, 1818.

MY DEAR JONES,

I have with much pleasure read your account of the War in Spain, Portugal, &c., and I am desirous of some alteration or explanation of the statement in the appendix G relating to the manœuvre of discomfiting Columns of attack by Troops in line; because it appears to me that should the statement be left as it now is, in a work of military history; and should it be in future acted upon against great disparity of numbers, it might be productive of very fatal consequences.—The effect produced by the arm under my charge having been mentioned renders it incumbent on me to furnish you with every information in my power, and in so doing I trust I shall not be supposed to intend, in the slightest degree, to derogate from the merit due to the brave and noble conduct of the 50 Regt. or its commander on that day, as it is with unfeigned pleasure I inform you, that from Colonel (now Maj.-Genl. Sir George) Walker and that Regt. I received support and co-operation which I shall remember and be proud to acknowledge while I live.

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It would appear by the appendix G that the 50 Regt. under Col. Walker, and three Guns under my orders were the only Troops posted to oppose the advancing French Column, now the fact was that the advanced guard of Sir Arthur Wellesley's army consisting of the 5 Battn. 60th (four Companies) and 2 Battn. 95th (five Companies) Light Troops and the 50 Regt. with a half Brigade of Light 6 Prs. were under Brigr.-Genl. (now L.-Genl. Sir Henry) Fanes orders posted on a rising ground covering the village of Vimieiro, and forming the right of the Army ; the two Light Battns. being in advance in some enclosed ground, leaving the 50th supporting the Guns, to which two 9 Prs. of the Reserve had been added in the previous disposition ; and the 7th Brigade consisting of the 2nd Battns. of 9th, 43d and 52d under Brigr.-Genl. Anstruther formed in the morning on the right of Genl. Fane, their flank being covered by the 20 Light Dragoons and some Portuguese Cavalry.

The Light Troops of Genl. Fane were engaged with those of the Enemy and retired before superior numbers, and the artillery having opened on the debouche of the Column I went to the spot, when Genl. Fane directed me to bring up what remained of the Reserve viz. one 9 Pr. and one Heavy Howitzer, these were placed by me at the junction of the roads below the knoll and bearing on the Column and the Cavalry of the Enemy. They remained so posted until the inequality of ground hid the advancing column from them, at which time Genl. Fane and Col. Walker came near and remarked to me that the Guns would be in danger ; I replyed I was aware of it, and if the Genl. would permit the 50th to show itself they should be taken up the knoll : this was instantly acquiesced in, Col. Walker effectually shewed the support, and the Guns were placed, and opened with the others, every shot from seven pieces of Ordnance passing into and through the Column, and you will know the effect when I mention to you that the point at which the column halted, apparently to deploy, but from whence confusion began, was little more than one hundred yards from the Guns.—The instant was seized.—The Guns ceased firing :—not because " they could no longer be served " for they were on the commanding ground, secure, and in full action ; but by Genl. Fanes order to me, that the manœuvre which by his approbation Col. Walker with the 50th made might take place, as its execution placed part of the Regt. in the line of fire.—The Manœuvre was gallantly executed and its effect on the column complete. The French Cavalry formed to support their flying Infantry and received some Shot from the Guns and the Troops on the right, but were immediately in their turn charged by the 20 Lt. Dragoons and a few Portuguese Cavalry under Col. Taylor and driven in confusion through the remains of their Infantry Column.

You will perceive that it is by no means meant to assert that the Artillery alone routed the Column which attacked the right of the

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British Army on the day of Vimieiro; but that the natural effect of Seven Pieces of Ordnance well served, upon a column of 5,000 Men within so short a distance was, so to shake that Column, as, together with the appearance of the other Troops ready to act, to enable a gallant Regiment of 900 to make the charge producing the effect described, and which effect was rendered complete by the subsequent charge of Cavalry: And the conclusion which I draw therefrom is, that without such preparation and support it would have been impossible in the instance quoted to have produced any such effect, and might in any future case, lead to fatal error, if a small body of *One* thousand should of itself attempt by disposition or manœuvre to discomfit a Column of *5000* under a front equal to half its own.

To render the Column as an instrument of attack efficient, the first revolutionary French, and afterward Buonaparte, appear to have followed the tactique of Guibert and to have used artillery on all occasions in large Masses, aptly styled "Tete de Marteau" to throw into confusion the part of a line they wished to penetrate and turn; and while the artillery of the opposing armies were little moveable, or frittered away in Battalion Guns the attack by Column was fully successful: But the Column is in itself most defective when Masses of artillery can be brought to bear upon it.—The example of Talavera you have already quoted, and could furnish other examples from the operations you have witnessed, and you well know that in latter instances it was the means by which Buonaparte most frequently attacked the Column.

Though I have thought it right to give you the foregoing statement, I perfectly agree in the conclusion you draw respecting the defectiveness of the heavy close Column for the purpose of attack; and in its being unworthy of the celebrity some time attached to it.—And the result of that part of the day of Vimieiro appears to me to be most satisfactory in a military point of view when taken as an example of what can be effected even by small bodies of determined Troops of different arms, when acting by combined movements under a skilfull leader, and Genl. Officers in whom they have confidence.

The French public dispatch having asserted that the knoll at Vimieiro was found unattackable from entrenchments; It is right for me to say, that no spade had entered the ground except the two with each gun, to level the spot on which it stood; but the general Instruction of the late Lt.-Genl. Sir W. Congreve was strictly attended to, by keeping so much of the knoll in front as, without lessening the effect would in some measure cover both Guns and men; and to this I attribute the smallness of the loss sustained by the artillery on that spot.

Excuse the length of this and believe me ever truly yours

W. ROBE.

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(3). *Lord Wellington's Memorandum and Instructions for the Construction of the Lines of Torres Vedras.*

MEMORANDUM, OCTOBER 20TH, 1809, LISBON.*

In considering the relative state of the strength and efficiency of the allied and French armies in the Peninsula, it does not appear probable that the Enemy have it in their Power to make an attack upon Portugal.

They must wait for their Re-inforcements and as the arrival of them may be expected it remains to be considered what Plan of defence shall be adopted for this Country.

The great object in Portugal is the possession of Lisbon and the Tagus and all our measures must be directed to that object. There is another also connected with that first object which we must likewise attend—viz' the embarkation of the British troops in case of a Reverse.

In whatever season the Enemy may enter Portugal, he will probably make his attack by two distinct Lines—the one north and the other south of the Tagus, and the System of defence to be adopted must be founded upon this general basis.

In the winter Season the River Tagus will be full, and will be a barrier to the Enemy's Enterprizes with his left attack not very difficult to be secured. In the summer season however the Tagus being fordable in many places between Abrantes and Salvatierra and even lower than Salvatierra care must be taken that the Enemy does not by his attack directed from the South of the Tagus and by the passage of that River cut off from Lisbon the British Army engaged in operations to the Northward of the Tagus. The object of the Allies should be to oblige the Enemy as much as possible to make his attack with concentrated Corps. They should stand in every position which the Country could afford such a length of time as would enable the People of the Country to evacuate the Towns and Villages, carrying with them or destroying all Articles of provisions and Carriages not necessary for the Allied Army—each Corps taking care to preserve its communication with the others and its relative distance from the point of Junction.

In whatever Season the Enemy's attack may be made, the whole Allied Army after providing for the Garrisons of Elvas, Almeida, Abrantes and Valença, should be divided into three Corps, to be posted as follows:—One Corps to be in the Beira; one Corps to be in the Alemtejo; and the third consisting of the Lusitanian Legion, 8 Battalions of Chasseurs, one of Militia in the Mountains of Castello Branco.

In the winter the Corps in the Beira should consist of Two-thirds of the whole number of the operating army. In the Summer the Corps in the Beira and in Alemtejo should be nearly of equal numbers.

I will point out in another Memorandum the Plan of Operations

* The orthography is as written in the manuscript.

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to be adopted by the Corps North and South of the Tagus in the Winter Months.

In the Summer it is probable as I have before stated that he will make his attack in two principal Corps and that he will also push on through the Mountains between Castello Branco and Abrantes. His object will be by means of his Corps south of the Tagus to turn the Positions which might be taken in his front on the north of that River, to cut off from Lisbon the Corps opposed to him and to destroy it by an attack in front and rear at the same time. This can be avoided only by the retreat of the right centre and left of the Allies and their Junction at a point at which from the State of the River they cannot be turned by the passage of Tagus by the Enemy's left.

The first point of defence which presents itself below that at which the Tagus ceases to be fordable, is the River of Castenheira; and here the army should be posted as follows :—Ten thousand allies including all the Cavalry, in the Plain between the Tagus and the hills—5,000 Infantry on the hill to the left of the Plain; and the remainder of the army, with the exception of the following detachments, on the height in front and on the right of Cadafoes.

In order to prevent the Enemy from turning by their left the Positions which the Allies may take up for the Defence of the high Road to Lisbon by the Tagus, Torres Vedras should be occupied by a Corps of 5,000 men; the height in the rear of Sobral de Monte Agraça by 4,000 men, and Arruda by 2,000 men.

There should be a small Corps on the height E. by S. of the heights of Sobral to prevent the Enemy from marching from Sobral to Arruda, and there should be another small Corps on the heights between Sobral and Bucellas.

In case the Enemy should succeed in forcing this Corps at Torres Vedras or Sobral de Monte Agraça or Arruda. If the first, it must fall back gradually to Cabeça de Montachique, occupying any defensible point on this Road. If the second, it must fall back upon Bucellas; destroying the Road over the height of ——. If the third it must fall back upon Alhandra, disputing this Road, particularly at a point one league in front of that town.

In case any one of these three positions should be forced, the Army must fall back from its position as before pointed out, and must occupy one as follows—

5,000 men principally light Infantry, on the hill behind Alhandra; the main body of the Army on the Sierra of Servas with its right on that part of the Sierra which is near the Casal de Portella, and is immediately above the Road which crosses the Serra from Bucellas to Alverca; and its left extending to the Pass of Bucellas. The Entrance of the pass of Bucellas to be occupied by the troops retired from Sobral de Monte Agracia and the Cabeca de Montachique by the Corps retired from Torres Vedras.

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In order to strengthen the several Positions it is necessary that different works should be constructed immediately and that arrangements and preparations should be made for the Construction of others.

Accordingly I beg Colonel Fletcher as soon as possible to renew the several Positions.

1. He will examine particularly the effect of damming up the mouth of the Cartanhaira River, how far it will render the river a Barrier and what extent it will fill.

2ndly. He will calculate the labour required for that Work and the time it will take, as well as the means of destroying the Bridge over the River and of Constructing such Redoubts as might be necessary on the Plain, and on the Hill on the left of the Road, effectually to defend the Plain. He will state particularly what means should be prepared for these Works.

He will also consider of the means and time required and the effect which might be produced by Scarping the banks of the River.

3rdly. He will make the same Calculations for the works to be Executed on the Hill in front and on the right of Cadafoes; particularly on the left of that Hill to shut the entry of the Valley of Cadafoes.

4thly. He will examine and report upon the means of making a good road of Communication from the plain across the Hills with the Valley of Cadafoes, and the left of the proposed Position, and Calculate the time and Labour it will take.

5thly. He will examine the Road from Otta by Abrigola, Lebougeira to Merciana, and thence to Torres Vedras; and also from Merciana to Sobral de Montegaçia.

He will also examine and report upon the Roads from Alenquer to Sobral de Montegaçia.

6thly. He will entrench a Post at Torres Vedras for 5,000 men. He will examine the Road from Torres Vedras to Cabeca de Montachique; and fix upon the spots at which to break it up might stop or delay the Enemy, and if there should be advantageous ground at such spots he will entrench a Position for 400 Men to cover the retreat of the Corps from Torres Vedras.

7thly. He will examine the Position of Cabeca de Montachique, and determine upon its line of defence, and upon the Works to be constructed for its defence by a Corps of 5,000, of which he will estimate the time and Labour.

8thly. He will entrench a Position for 4,000 on the two heights which command the Road from Sobral de Montegaçia to Bucellas.

He will entrench a Position for 400 men on the height of St. Ajuda between Sobral and Bucellas to cover the Retreat of the Corps from Sobral to Bucellas; and he will Calculate the means and the time it will take to destroy the Road at that spot.

9thly. He will construct a Redoubt for 200 men and three guns at

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the Windmill on the height bearing E. by S., and E.S.E. from the height of Sobral de Montegaçia; which guns will bear upon the Road from Sobral to Aruda.

10. He will ascertain the points at which and the means by which the Road from Sobral to Aruda can be destroyed.

11*thly*. He will ascertain the time and labour required to entrench a Position which he will fix upon for 2,000 men to defend the Road coming out of Aruda towards Villa Franca and Alhandra.

12*thly*. He will fix upon the spots at which the Road from Aruda to Alhandra can be destroyed with advantage.

13*thly*. He will construct a Redoubt on the Hill which Commands the Road from Aruda, about one league in front of Alhandra.

14*thly*. He will examine the little rivers at Alhandra and see whether by damming them up at the mouths he could increase the difficulties of a Passage by that place—and he will ascertain the time and Labour and means which this Work will require.

15*thly*. He will fix upon the Spots and ascertain the time and Labour required to construct redoubts on the hill of Alhandra on the right and prevent the passage of the Enemy by the High Road—and on the left and in the rear to prevent by their fire the occupation of the Mountains towards Alverca.

16. He will determine upon the Works to be Constructed on the Right of the Position upon the Serra de Serves as above pointed out to prevent the Enemy from forcing that point, and he will calculate the means and the time required to execute them. He will likewise examine the pass of Bucellas, and fix upon the Works to be constructed for its defence and calculate the means, time and Labour required for their execution.

17*th*. He will calculate the means, time and Labour required to construct a work upon the Hill on which a Windmill stands at the Southern Entrance of the Pass of Bucellas.

18*th*. He will fix upon the Spots on which Signal Posts can be erected upon these Hills to Communicate from one of the Positions to the other.

19*th*. It is very desirable that we should have an Accurate Plan of this ground.

20*thly*. Examine the Island in the River opposite Alhandra, and fix upon the spot, and Calculate the means and time required to construct Batteries upon it, and play upon the approach to Alhandra.

21*stly*. Examine the effect of daming up the River which runs by Loures; and Calculate the time and means required to break the Bridge at Loures.

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THE REPORT OF THE ROYAL COMMISSION ON COAST EROSION.

By COLONEL W. PITT, LATE R.E.

THE Royal Commission on Coast Erosion has recently issued its Report. This is a very interesting publication which should be in the hands of every R.E. officer who is responsible for the maintenance of the foreshore of War Department property. It can be obtained from Messrs. Wyman & Sons, 109, Fetter Lane, E.C., for the small sum of 3s. 5d. including postage.

The Report is divided into parts dealing respectively with the following subjects :—Physiographical and Geological Considerations, Extent of Erosion and Accretion in recent years, Engineering (Sea Protection Works), Administration, Reclamation of Tidal Lands, and Grants from Public Funds. It is signed by the whole of the members of the Commission subject to reservations on certain points, appended by four of them.

It is proposed in the following notes to give a brief review of the Report and recommendations under each of the heads mentioned above, and to deal somewhat more fully with that part relating to engineering questions, as this is what especially bears upon the protection of the foreshore.

I contributed a paper on "Coast Erosion and its Prevention" to the June issue of the *R.E. Journal*, 1908. The facts and opinions therein put forward are in close agreement with those to be found in the Report of the Royal Commission.

Part I. of the Report opens with a consideration of the recent changes of level of land and sea, using the term recent in its geological sense. The raised beaches found in many places and submerged forests in others clearly show that such changes have taken place; moreover the sea lochs on the west coast of Scotland and the inlets on the west coast of Ireland are all drowned valleys, similar to the Norwegian fiords but on a smaller scale. There is not sufficient evidence to enable us to say whether movements causing these changes are in progress now or are likely to recur. A brief description is given of the geological conditions affecting the coast and the way in which erosion is caused by weathering of cliffs and the action of the sea. This part of the Report is in agreement with what was stated in my paper in this *Journal* but not being subject to limitations as regards space is naturally fuller. There are, however,

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some remarks in para. 42 (1) of the Report which call for comment. It is stated that the supply of beach material derived from the sea bed may be regarded as negligible. As evidence against this opinion may be quoted the great quantities of coal washed up on the north-east coast of England sufficient to make it worth while for people to collect it in baskets and take it home for use. This coal must come from an outcrop in the sea bed, and if coal can be washed up why not shingle and sand? The following is an instance of shingle apparently coming from below low water mark. About two years ago the sea wall in front of the King's Bastion at Portsmouth, extending from the Clarence Pier towards the entrance to the harbour, failed owing to the sea breaking over the top, washing out the filling behind, which had no covering of asphalt, and scouring out the foundations already exposed by denudation of the beach. The wall was repaired and four groynes constructed in front of it on the steep beach. This would seem to be a most unpromising place for the erection of groynes. There can be no travel of shingle from the south because it cannot get round the pier, nor from the north because, although there is plenty on the beach between Forts Monckton and Blockhouse, it cannot get across the mouth of the harbour. Yet beach material has accumulated and the ends of the groynes at the toe of the sea wall are now covered with shingle. This certainly appears to have come from below low water mark, except a small quantity which was replaced by hand from the accumulation drifted up against the pier.

The Commission bring to notice one point which is not referred to in my paper for the sufficient reason that it had not occurred to me. The supply of beach material is derived from erosion of cliffs. This material is subject to the wear and tear of travel, the sand is carried out to sea in solution and the pebbles are worn away gradually by friction. It is obvious therefore that were we able absolutely to check erosion at all points the source of supply would be cut off, and in course of time the beach material would disappear. This is however such a remote contingency that our regard for the interests of posterity need hardly lead us to restrict our protective measures because of it.

After describing the formation of "Accretions" the Report goes on to give in considerable detail an account of the geological features of the entire coast line of England and Wales, Scotland and Ireland. This occupies 16 pages of the Report and need not be referred to here. At the end of Part I. the Commissioners give a number of "conclusions." Two only of these call for notice; one, that "there is no evidence that any changes in the relative levels of land and sea are now in progress except possibly a slight submergence on the coast of Northumberland, in the extreme north of Scotland, and on the south and west of Ireland"; the other that it is important that

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artificial structures erected on the shore should not arrest the flow of shingle to the detriment of the shore on their leeward side. This latter point was referred to in my paper.

Part II. of the Report deals with the extent of erosion and accretion in recent years. Investigations into this question can only be carried back with any degree of accuracy for about 60 years owing to the lack of reliable maps of an earlier date. Old maps showing the coast line are frequently very misleading. My paper already referred to was accompanied by a reproduction of a map of Romney Marsh, compiled by Colonel Hickson, D.S.O., showing the coast line at different periods. According to one of the maps consulted by him high water mark in 1736 was half a mile inland of Dymchurch, an obvious impossibility. Old maps should be treated with suspicion unless supported by other evidence.

Colonel Hellard, C.B., late Director-General of the Ordnance Survey, prepared for the Royal Commission a statement of the losses by erosion, and gains by accretion, in the United Kingdom during the last 35 years. It appears that the losses have amounted to 4,692 acres, and the gains to 35,444 acres, making a net gain of 30,752 acres. This last total includes the area of artificial reclamations. Viewed as a financial transaction the balance would possibly be the other way. Land lost by erosion had mostly a fair market value ; that gained by reclamation should be valued at the difference between the cost of the necessary works and the price obtainable for the land reclaimed, sometimes a negative quantity. Land gained by natural accretion has very little value until it has been for several years out of reach of the tide, and even then it is sometimes covered with sandhills and is worth nothing except to let for rifle ranges.

Thirty-five pages of Part II. of the Report are devoted to an abstract of a vast amount of evidence giving details of the erosion and accretion in progress round the coast of the whole of the United Kingdom, and the steps taken in each case to protect the foreshore.

Part III. deals with "Engineering (Sea Protection Works)." The opening paragraphs describe the action of tides, waves, and winds in almost the same words as will be found on page 346 of the *R.E. Journal*, June, 1908. The facts of course were well known. There is a statement in para. 8 of this Part which seems open to question. It is said that "offshore winds cause beaches to heap up in the vicinity of high water level" and that inshore winds flatten the slope. This statement is presumably made on evidence given before the Commission but it sounds rather doubtful.

Evidence was taken regarding sea walls, and the relative merits of various profiles, vertical, battered, or curved. The Commission came to the conclusion that a battered face is best but gave no opinion as to whether the face should be smooth or stepped. It is

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generally, I believe, considered that a wall should be built in steps with very small treads, in order to break up the backwash.

Sea walls, if successful, protect the feet of cliffs from erosion but in no way prevent them from falling and slipping. As has already been pointed out the loss is usually primarily due to this cause, and it is therefore necessary to slope and drain the cliff to prevent its softening and slipping forward due to the action of land water. This it may be remarked is sometimes a very difficult operation. Reference was made in my previous paper to the new Marine Drive round the Castle Hill at Scarborough. The cliffs at the back of the drive are slipping badly. On the top of the hill is a depression in which are two small ponds. Soakage from these undoubtedly finds its way to the face of the cliffs and, until the ponds are done away with, slipping is bound to go on.

The subject of Groynes is next dealt with but unfortunately it is treated in a rather cursory manner. This is the more to be regretted as there are such extreme divergences of opinion amongst engineers as to the relative merits of high and low, long and short groynes, of timber and concrete for materials, as to the distance apart at which they should be constructed, and whether they should be at right angles to the beach or inclined. Mr. Wheeler, the author of *The Sea Coast*, gave evidence with regard to "Case" groynes. These were strongly advocated by the late Mr. E. Case. The principle of them is that they are of timber, long and low, and raised gradually as the beach makes up. They are described in my earlier paper. Mr. Wheeler said "Case groynes are no use where you want to protect shingle * * * Where there is shingle the groyne must be much stronger and much higher, because shingle will collect 5 or 6 feet on one side, and, of course, the groyne must be sufficiently strong to stand the shingle pushing against it." With the greatest deference to such a high authority as Mr. Wheeler it is submitted that the shingle should not be allowed to collect 5 or 6 feet high against a groyne. The object in view should be to get a beach with regular contours parallel to high water mark, and not a series of zigzags. This can only be attained by making groynes low in the first instance so that the sand or shingle can drift over the top of them and thus raise the whole beach gradually. As the level of the beach rises more boards should be put in until the desired profile is obtained. As I pointed out in my earlier paper there are on the South Coast of England some glaring examples of the evils of high groynes, notably at Eastbourne. Shingle may be seen piled up against timber groynes, 15′ higher on the windward side than the leeward, and to keep up this enormous weight huge timber struts are required. High groynes accumulate in one place more shingle than is required, and keep it away from places where there is a deficiency. However the authorities at Eastbourne appear to realize the mistake made, as the

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Borough Surveyor of that town gave evidence before the Commission to the effect that the Corporation had recently been constructing low groynes "leaving the piles sufficiently high to build up the groyne as the beach accumulates." Some witnesses advocated the provision of scupper holes to allow the shingle to drift through, and the Commissioners rather endorsed this recommendation but it seems doubtful whether it would answer.

It is satisfactory to note that the Commission recorded an opinion that in many cases groynes have been constructed unnecessarily high, and consequently injuriously affected the coast to leeward of them, and caused excessive erosion. The perfectly sound principle is laid down that "the most effective groynes are those which produce the least differences, generally, in the beach level, on the windward and leeward sides."

As regards length of groynes it is recommended that they should extend from the shore to the vicinity of low water spring tides, and occasionally even further seaward. The distance apart should generally be about equal to the length.

The witnesses examined differed considerably in their views as to the angle to the shore at which groynes should be constructed. The conclusion arrived at was, that a direction at right angles to the shore or pointing slightly to windward would be most effectual.

There was also a great difference of opinion amongst the witnesses as to the life of groynes. Those of concrete are said to be practically permanent. This seems rather optimistic; it is questionable whether any structure which the sea can get at should be regarded as permanent. Timber groynes of oak, jarrah and softer woods have varying lives dependent not merely on the material of which they are constructed, but to a great extent on local conditions. On the South Coast ferro-concrete is being tried. The objection to this material is that applying to all concrete groynes, viz. that they cannot conveniently be raised as the beach material accumulates.

It was stated that on the east coast timber groynes had been known to last 30 years. On the south coast, where there is more shingle and less sand the life of oak groynes was said to be from 15 to 20 years. This question is one which materially affects Corporations and other similar bodies because at present the local Government Board will only allow 10 years for the repayment of loans for the construction of timber groynes and 20 years where concrete is used.

The Commission took a great deal of evidence as to the cost of groynes. Concrete is of course the most expensive material. At Hastings the cost was about £3 a foot-run, and the upkeep of 64 groynes at the same place averaged over £17 each per annum. At Brighton concrete groynes cost on the east side £4,818 each, and in

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the west £3,000 each. The length varied from 255 to 465'. These were however enormous structures 24' high above the chalk foundation and carried up 12' above high water mark.

As regards timber groynes some witnesses gave the total cost without stating the length, a useless piece of information. The Borough Engineer of Eastbourne gave 25s. per foot-run. Other witnesses 26s. 6d. at Sandgate and St. Margaret's, 22s. to 23s. at Dover, and also at Dover £1 to 30s.

In my previous paper I referred to Mr. Wheeler's quotations of 16s. 9½d. *per yard* for low groynes and 19s. 2½d. *per yard* for "Case" groynes. These estimates are far below those given before the Royal Commission, and are probably too low.

The report calls attention to the fact that in many places on the coast the cost of adequate protection by groynes would exceed the value of the land liable to be eroded. This is not a consideration which need as a rule trouble R.E. officers, though there may be exceptional cases where land is not worth protecting, and its loss would not affect defence works.

The "conclusions" given at the end of this part of the Report have mostly been embodied in the foregoing remarks. It is pointed out in addition that it is necessary that there should be some central authority controlling defence works, with power to prevent local authorities from unduly holding up beach material to the detriment of their neighbours.

A Committee of the Commission examined the foreshore defence work in Holland and Belgium and plates are given in the Report illustrating some of them. It was considered however that the circumstances in these countries are so different that these works do not afford examples to be followed.

In Part IV. of their Report the Commissioners consider questions of "Central and Local Administration." The matters dealt with are to a large extent of a legal nature and as is usually the case the more a mere layman studies the questions raised and the evidence given the less it seems possible to arrive at a clear understanding of what the law really is. Take for instance the question of the ownership of "accretions." I defy any owner of land adjoining the foreshore who may have an "accretion" fronting his property to ascertain from what is said in the Report whether he can legally claim the accreted land or not. Should such a case arise with reference to W.D. property I should advise the officer in charge to take steps to get the land brought on his "Property Statement" and set up boundary stones. Any other person claiming it would then have to make out a better case. This is an important matter because if no such steps were taken we might have fishermen's huts built on an accretion and obstructing the fire of a battery or view from a

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P.F. cell. When buildings are once erected it is difficult to get rid of them.

The various sections of Part IV. deal with the law relating to the foreshore, the respective powers of Government departments and local authorities, and the changes in the law which appear to be necessary. Space does not admit of more than a few brief references to this portion of the Report which moreover, though of considerable interest, does not much concern officers who have charge of W.D. property with a sea frontage.

The first point brought to notice is that the word "foreshore" has different meanings in England, Scotland, and Ireland. In England the Courts have decided that the landward limit of the foreshore is high water mark at medium tides, no seaward limit being defined. It has never been decided whether this is applicable to Ireland so that the foreshore is there an unknown quantity legally. In Scotland it extends from high water mark at ordinary spring tides to low water mark of the same tides. Primarily the foreshore is the property of the Crown; part is under the charge of H.M.'s Commissioners of Woods and Forests and part under the Board of Trade, but a great deal of it has been permanently alienated. In many cases the War Office has had to pay to private owners preposterous sums for the right to fire over the foreshore in front of batteries. In England and Ireland the only rights vested in the public are those of navigation and fishing. There is no right of way at low water. In Scotland there appears to be a right of way.

The Board of Trade exercises jurisdiction over the foreshore as regards navigation and its consent is required to the construction of any groynes, piers, or similar works, which may affect navigation. It is not clear that the Board can interfere where the foreshore is not Crown property, but however that may be the War Office invariably asks for the Board's authority to construct groynes even where the foreshore has been acquired. By Act of Parliament the Board of Trade can issue an order prohibiting the removal of stone, shingle, etc., from the foreshore anywhere in the United Kingdom.

Many pages of the Report are devoted to a detailed account of the local authorities "having powers and duties in relation to the regulation of the foreshore or to sea defence." They are Commissioners of Sewers, Drainage Boards, Harbour Authorities, County and Borough Councils, Urban and Rural District Councils, etc., etc. Their name is legion, and their powers and duties as varied as it is possible for them to be. I referred briefly to this subject in my paper in this *Journal* for June, 1908, and do not propose to say any more about it here beyond remarking that there are large stretches of dangerous foreshore for which no one is responsible but the adjacent owner. This gentleman may neglect his sea wall and imperil hundreds of acres of his neighbour's property with impunity. I quoted a flagrant

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instance of this close to Dymchurch Redoubt near Hythe. The "Recommendations" of the Commission are lengthy, but some of the more important may be mentioned. It is proposed that all Crown foreshores should be controlled by the Board of Trade; and that a right of way over all foreshores should be granted to the public. As regards sea defence it is recommended that the Board of Trade should be constituted the "Central Sea Defence Authority" for the United Kingdom, with the necessary powers of control over existing local authorities, and with power to create new authorities where required. The working out of this scheme is given in the Report in considerable detail. It is also recommended that it should be made illegal to remove any material from the foreshore without the consent of the Board of Trade.

In Part V. of the Report consideration is given to the Reclamation of Tidal Lands. It is pointed out that reclamations are of two kinds, viz. those undertaken for commercial purposes such as making docks, etc., and those carried out with a view to obtaining agricultural land. In the first case a large expenditure on the necessary works is usually justified by the results to be obtained. Where however the object in view is the reclamation of land for agricultural purposes the cost to be incurred is a matter for very careful consideration, and the operation is to a large extent of a speculative nature. The value of agricultural land has for some years been on the down grade and there is every indication that the decline will be progressive. It is indeed highly questionable whether there is any land which could be reclaimed at a cost which would not exceed the value of the acreage gained.

The estimated cost of reclamations as put before the Commission by different witnesses varied remarkably. A farmer from Fingringhoe, near Colchester, said that 600 acres could be reclaimed in his parish for £2,500. On the other hand works in Morecambe Bay necessary to reclaim from 400 to 500 acres were estimated at £1,500,000. It should be stated that in the latter case the object in view was primarily to prevent sea water percolating into mines. The scheme has not been carried out. Evidence was given as to many other reclamations proposed in different parts of the country. Few, if any, of them held out an alluring prospect to the cautious investor.

The Commission next proceeded to consider the question of utilizing the labour of the "unemployed." This *Journal* is not concerned with economic problems of this kind and it will therefore suffice to quote the "conclusions" of the Commission.

As regards industrial reclamations the Commissioners were of opinion that these are matters which may safely be left to the Corporations or other bodies proposing to undertake them. In the case of schemes for agricultural reclamations they considered that the

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State should facilitate the carrying out of such works with a view to lessening unemployment; but that the evidence tended "to show that such reclamations would not be profitable from a financial point of view." With reference to the "unemployed" the opinion is recorded that the utilization of their labour would increase the cost of the work to be carried out, but that on the other hand it would have the effect of saving men from being supported out of the rates. It is suggested that the Board of Trade should, in conjunction with the Development Commissioners, frame schemes, and that the latter body should advance the necessary funds.

Part VI. deals with the legal question as to whether it is, or is not, the duty of "the Crown to defend the coast of the Kingdom from the inroads of the sea." It was contended by the "National Sea Defence Association" that the responsibility "rests primarily upon the nation at large." The Town Clerk of Lowestoft appeared on behalf of the Association and stated the grounds on which their contention is based, in a lengthy legal argument going back to feudal times.

The solicitor to the Board of Trade presented the opposite view of the case. The opinion of the Commissioners is that they cannot adopt the principle that there is a responsibility for sea defence resting primarily upon the nation at large; and that all they can do is to consider whether there are special reasons from a national point of view which would justify the making of grants from public funds in aid of defence works. Their conclusion is that there is no justification for such a course.

The Report is signed by the whole of the Commissioners, but subject to certain reservations on the part of four of their number.

One member has appended a lengthy statement on the question of the liability of the Crown to protect the realm from the sea, and contends that this obligation is imposed on the Sovereign by his Coronation oath, and has been so imposed ever since the Magna Charta of Henry III. This member records his opinion that the Sovereign is just as much bound to protect his dominions from the inroads of the sea as from invasion by an enemy, and that consequently sea defence is a national service and should receive national aid.

Two members have signed a "reservation" disagreeing with the recommendation made in Part IV. that it should be illegal to remove material from the foreshore without the consent of the Board of Trade. This they consider too drastic a measure.

The third "reservation" does not take exception to anything in the Report but advocates legislative action regarding the definition of the term "foreshore" so far as Ireland is concerned with a view to the adoption of the limits in force in Scotland. This Commissioner would like to see the same course adopted as regards England and Wales but admits that the legal obstacles are insuperable. In Ireland

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there has never been any decision by the Courts and consequently there is nothing to upset.

I took up the Report of this Royal Commission with much curiosity as to whether it would be necessary for me to modify any of the statements of fact, or opinions, or recommendations, put forward in my paper written three years ago. Having carefully studied the Report I do not see that it is in conflict with anything in my paper but on the contrary it supports all that I said. The only alteration I might feel disposed to make is one touching the cost of timber groynes. Reference is made above to Mr. Wheeler's estimates quoted in my original paper. These seem to be too low, but I recommended that in all cases detailed estimates should be prepared as the only reliable means of arriving at the cost of a groyne.

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ECHOES FROM THE ENGINE ROOM.

(*Continued*).

By "INSPECTOR."

ECHO NO. 12.

FLYWHEEL *v.* NON-FLYWHEEL PUMPS.

In connection with some correspondence regarding pumping machinery with one of the leading British firms manufacturing such plant "Inspector" received a letter containing the following paragraphs :—

"You will notice that we have proposed to use Rotative Engines, *i.e.*, engines provided with flywheels, in every case. There is no doubt that where water is within suction distance pumping engines of this class are the best.

"Because 1. The flywheel contains a store of energy, so that the engine will finish up the stroke even after the steam has been cut off, so that the steam can be used expansively and therefore economically."

"Because 2. The flywheel engine fitted with a crankshaft and connecting rod makes a constant stroke irrespective of the care of the attendant, and therefore, the losses through clearance, while always less than with a Non-Rotative engine, such as a "Worthington" or one of our own Differentials, are constant, and are not liable to be increased through short stroking, which almost always takes place at times with non-rotative engines."

"Because 3. The flywheel engine is on the whole safer than the non-rotative type, since there is no liability to strike the covers in the event of a burst pipe causing loss of head."

These remarks are of great interest, and their value is the greater since they emanate from a firm who have done most of their business in "Straight Line" pumps.

The majority of the pumping plants visited by the writer in his *rôle* of inspector are of the "Worthington" type. In nearly all these plants short stroking is the rule under ordinary working conditions,

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and a similar state of affairs has been observed in the case of other Worthington pumping engines visited. A reason for this may be assigned. Short stroking tends to safety, as the chances of the moving parts striking the end covers is thereby lessened. Speaking from personal experience it is found that if the pump is made to run at full stroke it will under ordinary circumstances shortly do one of two things. If the boiler pressure rises, even but a little, (an increase of 5 lb. on 100 lb. will suffice), the pump will begin to strike the end covers; if the boiler pressure falls the pump will run at a shorter stroke. With a flywheel pump the corresponding changes would be either an increased or diminished speed, but the length of stroke would remain constant. Now even under test conditions, when the supervision is more strict than can be economically provided in every-day work, it is not easy to keep the boiler pressure quite steady with any but first-class firemen, nor is it practicable to always keep a man on the engine stop valve. Hence there is some excuse for the ordinary attendant to run his straight line pumping engine somewhat below its full rated stroke. If the pumps are in good condition it has been found practicable during inspection tests of some hours duration, to run Worthington pumps even somewhat above their full rated stroke, and it is under such conditions alone that the most economical results in steam consumption are obtained. However for the reasons above stated, it would seem that the flywheel pump is more likely to live up to its guaranteed behaviour than is the "Straight Line" pump, in everyday work.

Since the length of stroke in a "Straight Line" pump is subject to alteration due to variation in steam pressure, this alteration will also occur if the load on the pump varies. If the load is increased above normal by undue friction (caused for instance by screwing down the piston and pump rod glands too tight) the efficiency will fall whether the pumping engine is of the flywheel or non-flywheel type, but in the latter case the length of stroke will also be reduced, and this tends to a still further loss of efficiency in consequence of the increased clearances in the steam cylinders. It should, however, be remarked that although the tendency to variation in the length of stroke is an inherent characteristic of the non-flywheel type, the actual offence *can* be prevented by attention to steam pressure, and by controlling the steam stop valve and the cushioning valves on the engine, or, in other words, by careful attendance. In large plants, working long hours, where it is justifiable to employ a highly skilled staff such attention can be reasonably looked for. Under those circumstances the straight line type is far more likely to, and does, hold its own as an economical performer.

The following extract from the '91 edition of Tangye's catalogue of pumping machinery has also a bearing upon this question :—

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"It may be worth while to explain why the principle of expanding steam cannot be used in ordinary direct° acting pumps to the same extent and with the economical results obtained with rotative engines. In pumping, the load of resistance is practically constant. In an ordinary direct acting pump, steam is admitted to the cylinder during almost the entire stroke, the driving force is thus also constant, and the pump works satisfactorily. Immediately an attempt is made to work expansively, the driving force is either excessive at the beginning of the stroke, sending the piston forward violently in a manner quite unsuited for pumping, or if the force is right at the beginning of the stroke it is too weak towards the end, the pump fails to complete its stroke and stops, or short stroking results; neither defect can be tolerated, and expansion must be sacrificed to certainty of action."

Compromise is necessary in many engineering schemes; having therefore formulated a case *against* the "Straight Line" type of pumping engine let us see if there is nothing to be said on the other side. Another extract may be taken from the letter already referred to :—

"Where water is to be pumped from deep wells or boreholes the first function of the flywheel, that of providing a store of energy, is performed by the weight of the rods, and steam can be used expansively without the use of a flywheel."

Now it is not to be supposed that steam is not used expansively in a straight line pumping engine. In a single cylinder engine of that type the amount of expansion is negligible, or at the best, very small. But in compound, and triple expansion engines the amount of expansion made use of is considerable even if the full pressure of steam is carried for nearly the whole of the stroke in the H.P. cylinder, and in triple expansion engines may amount to about 11 expansions by volume, depending on the ratio of the various cylinders, and on the point of cut off in the H.P. cylinder.

In a flywheel engine the rotation of the flywheel calls for a certain amount of power, or in other words the flywheel does not give back all the energy put into it. In the straight line pumping engine there is no "waste" of this kind, and the result is that the mechanical efficiency is higher than with the flywheel type, amounting to as much as 94 per cent. or more even in engines of 80 P.H.P. The mechanical efficiency of the large 400 P.H.P. flywheel pumping engines supplied for the Rand Water Board is given in the published reports as a trifle over 92 per cent., based upon the water actually pumped.

As regards ease of transport the advantage probably lies with the

° This term here means what are defined as "Straight Line" pumps n these notes.

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straight line type; this is so in the case of Worthington pumping engines as these are invariably made duplex, as has been already mentioned, and the consequence is the weight of the individual parts is less. There is moreover no relatively heavy flywheel or crankshaft to be dealt with.

Similarly as regards erection. The parts to be handled are smaller and lighter in the case of duplex pumps and no greater in other cases, and it is hard to imagine anything less difficult in the way of erection than the putting together of a straight line pumping engine.

In the case of borehole pumps (*vide* Echo No. 8) where a long stroke (*i.e.* long compared to the diameter of the bucket) is required, and there are in addition other factors to be considered, *e.g.* pausing at end of stroke, the straight line pumping engine has undoubted advantages. But just as there are many ordinary cases where straight line pumps have been installed for some reason in preference to flywheel engines, so also there are many instances of borehole pumps operated by engines of the latter type.

It is difficult to generalize as regards cost. Although manufacturers work to standard sizes, pumping engines, proper, as opposed to "Trade" pumps, are not made for stock. On the contrary, every order is a special one unless the requirement can be met either by a trade pattern or by assembly of stock parts. In the case of a duplex pump it must be remembered that this means duplication of all the principal parts, and this probably means a relatively high price. On the other hand if a "simplex" (as opposed to duplex) pump will meet the requirements of the case, a "Straight Line" pump will almost certainly be cheaper in first cost than a flywheel pump for the same duty.

In so far as a personal expression of opinion is permissible the writer has a decided preference for pumping engines of the flywheel type for all ordinary requirements, especially so where skilled supervision is costly, and when the size of the plant does not justify the employment of an expensive staff. In justice to the "Straight Line" type it should be stated that the many plants of this type already referred to have been in operation for several years, without, so far as is known, anything approaching a serious disablement, except in the case of one of the largest pumping engines which developed a cracked water end. (Reason not known; possibly water hammer set up in the long rising main by improper manipulation of valves. Probably nothing to do with the type of pumping engine). Nevertheless it does not follow from this that flywheel engines would not have given equally satisfactory service, and it is contended that they would have been more economical in steam (and fuel) consumption; no more costly in maintenance; and probably less expensive in the first instance (*i.e.* less costly than duplex "Straight Line" pumps).

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Echo No. 13.

WORTHINGTON PUMPS.

Although straight line pumps have already been mentioned and Worthington pumps have been referred to in general terms, the latter pumps call for some additional remarks.

The combination of duplex straight line pump in which the valve motion on one side is operated by the pump motion on the other side is believed to be due to H. R. Worthington. Be that as it may, pumps acting in that manner are often colloquially known as "Worthington" pumps although such pumps are nowadays made by many different firms. The most generally known form of "Worthington" pump is the ordinary duplex pump used for boiler feeding. The smaller sizes of such pumps are made with only one cylinder on each side and they are exceedingly simple in construction. In the larger sizes each side of the pump is made compound and is generally arranged with the L.P. cylinders nearest to the water end and the H.P. cylinders at the "back."

The next development was introduced in connection with pumping engines for water supply purposes and consisted in making each side of the pump triple expansion, the L.P. cylinders being still placed nearest to the water end and the H.P. cylinders at the "back."

This arrangement of steam cylinders was reversed in later designs in order, presumably, to simplify the working of the expansion valves referred to below.

All the foregoing pumps were fitted with D valves, but the triple expansion pumps were in addition provided with a Meyer expansion valve upon the back of each H.P. valve, the expansion valve on each side being operated directly off the piston rod on its own side.

In the double cylinder pumps (*i.e.* one cylinder on each side) the valve face has five ports viz. a central exhaust port and two other ports on each side of the centre. In the compound pumps the H.P. cylinders have only three ports in the valve face, but the valve faces in the L.P. cylinders are as above described. Similarly in the triple expansion pumps the L.P. cylinders have five ports in the valve faces but the valve faces of the I.P. and H.P. cylinders have only three ports. Further, in both the compound and triple expansion pumps the L.P. cylinders are fitted out with "cushioning" valves for controlling (to some extent) the length of stroke, and such valves are sometimes fitted in single cylinder straight line pumps.

Of the five ports above referred to the two outermost ports are connected by passages to the extreme ends of the cylinder and serve as steam supply ports only; dependent upon the position of the valve

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they are either covered by the valve or are open to steam; they never are, and cannot be, connected to the exhaust.

Of the other three ports the centre one is the exhaust port simply, and the two inner ports on either side of it are alternately connected to exhaust by the agency of the valve. They are either in the position of being connected to exhaust or covered by the valve; they never are and cannot be connected to steam. The passages connecting these two ports to the cylinder enter it at some little distance from the ends so that they are alternately closed by the piston before it reaches the end of its stroke. Considering one cylinder only it will be clear that when the piston starts on its forward stroke its valve will be right forward. In that position the outermost forward port will be covered by the valve, the other forward port will be connected by the valve to the exhaust port, the outermost back steam port will be open to steam, and the other back port will be closed by the valve; the valve remains in that position until the piston almost reaches the end of its stroke; in so doing, the piston closes the only passage by which the steam can escape from the forward end of the cylinder and a certain quantity of steam is thereby trapped in that end of the cylinder to serve as a cushion to arrest the motion of the piston.

Mention has however been made of cushioning valves. When such valves are fitted the two steam passages, referred to above, at each end of the cylinder are, respectively, connected together by a passage which is controlled by a screw down valve. Under the conditions above described it has been assumed that this valve was shut. If, however, the valve had been open the trapped steam would have been able to escape *viâ* the outer passage, through the connecting passage and so *viâ* the inner passage to exhaust. Under those circumstances the cushioning effect would be eliminated, and under certain conditions the piston would hit the end of the cylinder. The valves controlling the connecting passages described are called "cushioning valves" for sufficiently obvious reasons. By their judicious manipulation the piston may, on the one hand, be prevented from hitting the ends of the cylinder and, on the other hand the cushioning may be so controlled that the pump is enabled to make a full stroke. This matter has been dealt with at some length because this arrangement of steam control is common to all duplex straight line pumps, and moreover it appears that the use of the cushioning valves is often but little understood. The description will, it is hoped, be intelligible if a sectional drawing of a Worthington pump is referred to such as appears in a Worthington pump catalogue or in *Plate* XII. of the *Water Supply Manual* published by the War Office in 1909.

In every steam engine the internal length of the cylinder must be

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somewhat longer than the actual stroke of the piston. The excess of cylinder length over piston stroke should, generally speaking, be equally distributed at each end of the cylinder, and it will be convenient to call the excess at each end the "clearance length." In a flywheel engine the travel of the piston is definitely controlled by the throw of the crank, so that it is possible to make the clearance length quite small. It may be as small as $\frac{1}{8}$" for a piston stroke of 12". On the other hand in a straight line pump the internal length of the cylinder must be appreciably greater than the rated stroke of the piston, and a clearance length of $\frac{1}{4}$" for a rated stroke of 10" is quite usual. In other words the maximum possible stroke in such a pump—called the "contact stroke"—would be $10\frac{1}{2}$", whereas in actual working the travel of the piston would probably be somewhat less than 10". From this it will be clear why the clearance volume at each end of the stroke in a straight line pump is greater than in a flywheel pump. Further, although a flywheel pump may work stiffly and uneconomically due to a variety of causes, *e.g.* badly packed glands, the clearance volume is not altered. Similar causes in a straight line duplex pump will emphasize the want of economy in working by curtailing the length of stroke on each side and thereby increasing the clearance volume.

Most people who have to do with steam engines seem to know more or less how to set an ordinary D-valve operated by an eccentric. But although the setting of the valves of a Worthington pump of the type already referred to is a simpler matter, it does not appear to be equally well known to those who use such pumps. In these pumps there is always more or less "lost motion" in the valve work, and as the pins and other points of connection get worn the lost motion increases. The tendency of this increase is to lengthen the stroke of the pump, but provided this tendency does not become excessive, the slackness of the joints may be ignored until it is convenient to overhaul the pump. By "lost motion" is here meant the distance a valve rod can move without moving the valves, or in other words the "backlash" between the valve and the thing that moves it. The procedure for setting the valves is described in the general catalogue of the Worthington Pump Co. Briefly the method is as follows:—Place each piston in the middle of its contact stroke. Set each valve in its central position on its seating—in this position the valve will just cover the outer ports since these valves have no outside lap. Adjust the nut, or nuts, on each valve rod so that the lost motion is equally distributed on each side of each valve. The total lost motion will be about $\frac{3}{8}$" *i.e.* when the setting is correct each valve should have a movement of about $\frac{3}{16}$" on each side of its central position without moving the piston on the opposite side of the pump. If on putting the pump to work (it is assumed to be in good order) the stroke is

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found to be too short the lost motion may be increased, and conversely. These instructions apply to single cylinder, compound, and triple expansion pumps with D-valves, but in the case of pumps fitted with cushioning valves it should be remembered that the length of stroke can be controlled by these valves to a considerable extent independently of the lost motion. Also, if expansion valves are fitted the length of stroke can be regulated by their manipulation as well.

In *Plate* XII. of the *Water Supply Manual* already referred to is given a section of a compound Worthington pump. The object of the compensating cylinders illustrated on *Plate* XII. is described in the *Manual* and will not therefore be further referred to in these notes. Such cylinders are only fitted to pumps of large power. The pump illustrated has 5-ported valve faces on both H.P. and L.P. cylinders, and, as shown, the valves have considerable outside lap. The lap may be an error in the reproduction, but as regards the other point it is usual to have the double passages to each end of the L.P. cylinders only. "Inspector" has however come across one station containing two compound duplex Pearn pumps in which both H.P. and L.P. cylinders have the double passages, and each cylinder has also a pair of cushioning valves. This complication seems quite unnecessary.

The next variation to be referred to is the substitution of Corliss type valves for the D-valves in triple expansion Worthington pumping engines. The largest sizes of these pumps have entirely separate valves for steam and exhaust but such pumps do not come within the scope of these notes.

The ordinary D-valve has such well-known merits it may perhaps seem strange why it has been replaced by the Corliss valve. It is not necessary to discuss that point here. The valves in question work in liners forced into the cylinder castings and behave similarly to the corresponding D-valves except as mentioned below. The I.P. liners have three ports but both the H.P. and L.P. liner have five ports, and the L.P. cylinders are fitted with cushioning valves as already described. In place of the Meyer expansion valves, each H.P. cylinder has two entirely separate expansion valves, one for each end of the cylinder. The arrangement is clearly shown in the accompanying plate; this figure has been prepared from a blue print supplied by Messrs. J. Simpson and Co. The ports in the H.P. liners behave in the same way as do the ports in the L.P. liners, but whereas in the latter case the two ports on each side of the centre one are both connected to the L.P. cylinder direct, in the H.P. cylinders only the inner port is connected to its end of the cylinder, each outer port being connected to its corresponding expansion valve, and in this way, although admission and release are both controlled by the

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main valve, cut-off is governed by the expansion valves, if they are correctly set.

As regards the L.P. valves the figure is partly diagrammatic. The three ports shown in section, together with the valve covering them, behave exactly as do the corresponding parts in an ordinary D-slide valve, and in this respect the L.P. valve is similar to the I.P. valve. Actually each of the small ports "PP" is in line with the main steam port on its corresponding side and would not appear separately on a cross section through the valve chamber. The valve is so made that these small ports behave similarly to the outermost ports of a 5-ported valve face in the manner already described, *i.e.* each port "P" is either open to steam or covered by the valve, it cannot be connected to exhaust. Hence if the cushioning valves "V" are closed some steam is trapped at each end of the cylinder in turn, on the exhaust stroke, and cushioning occurs. If the valves "V" are open the cushioning effect is more or less eliminated according as the valves are more or less opened. Whether the valves "V" are open or shut steam is admitted to the extreme ends of the cylinder in turn through the corresponding port "P," and, after the piston has moved a little, steam is also then admitted through the other (main) connecting passage at the end of the cylinder affected.

As in the case of the "ordinary" Worthington pump the main valves of one side are operated off the piston rod on the other side of the pump, but the expansion valves are worked by the piston rod on their own side. Each valve is operated by a short arm keyed on to the valve spindle, and each valve has a travel of about 30° to 60° of arc depending upon the amount of lost motion allowed. As regards the expansion valves, when the valve is in the middle of its travel, its arm points upwards and outwards about 15° out of the vertical and cut-off occurs when the arm is inclined outwards at about 30°. The arms of all the other valves should point vertically downwards when the valves are in their central position.

Except as regards the expansion valves the setting of these Corliss valves, is, theoretically, no more difficult than is the setting of the D-valves. It is only necessary to put each side of the pump in the middle of its contact stroke and then to adjust the valve rods so that the valves are central with respect to their ports. There are however difficulties, which, although they need not be detailed here, are nevertheless sufficiently serious to justify a brief description of the procedure which has been found to give good results in practice, more especially so as no reference can be given to any literature dealing with the subject. It is assumed that each cylinder is fitted with indicator cocks, as should certainly be the case in a pump large enough to be built triple expansion.

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To set the Valves of a Worthington Pumping Engine fitted with Corliss Valves.

1. Put each side of the pump in the centre of its contact stroke. Insert chocks of wood to prevent the pistons moving.

2. Leave the expansion rod in position, but remove the expansion links and all valve rods.

3. Consider one side of the pumping engine only. Open the indicator cock to one end of the H.P. cylinder, and place the main H.P. valve to admit steam to that end of the cylinder. Turn on a very little steam, move the corresponding expansion valve by hand as required and so ascertain its point of cut-off; mark the position.* With the expansion valve open, similarly ascertain and mark the point of cut-off of the main valve. This should be the central position of the main valve, as these valves have no outside lap. Repeat for the other end of the cylinder; the mark for the point of cut-off of the main valve should coincide with the mark previously obtained, if it does not then the central position of the valve must be assumed to be midway between the two marks.

4. Turn the arm of the main H.P. valve vertically upwards so as to allow steam to pass straight to exhaust and so to the I.P. cylinder. Ascertain the central position of the I.P. valve in the way described above.

5. In a similar way ascertain the central position of the L.P. valve.

6. Repeat for the other side of the pumping engine.

7. The point of cut-off can be adjusted while the pump is running, but not so readily as in the case of a Meyer valve. Each expansion valve should cut off steam when its arm is inclined outwards at about 30 to 35° from the vertical; as a trial position place the expansion valves with their arms inclined outwards at about 15° to the vertical, this will give a cut-off at about 0·8 of stroke if the valves, spindles, etc., are as they should be. Fit on the expansion links making them all of equal length, the valves should then be symmetrical with reference to the cut-off points. In some pumps the expansion rods are adjustable and they may need alteration in order to bring the expansion valves symmetrical.

8. Eliminate the lost motion at the forward end of the H.P. valve rod, adjusting the screws so that the bolt which secures this end of the rod is in the middle of the slot.

* See above as to approximate position of the valve arm when cut-off occurs. If cut-off occurs only when the arm is in some very different position a reversed valve or badly twisted valve spindle is probably the cause.

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9. The length of each of the valve rods is adjustable. Place all main valves in their central positions and adjust the rods so that they all then fit on to the arms of the valves correctly, without moving the valves.

10. Remove the chocks referred to in "1" above, and move one side of the pump off its central position. If this is not done the pump will not start when steam is turned on as all the main ports are just covered by the valves.

11. It is desirable to put marks upon the pump on each side indicating the ends and middle of the contact strokes. The pump can then be readily "centered" when required and moreover when the pump is working it is easy to see how nearly the pump is making full stroke.

12. After setting the valves it is preferable to start up the pump without any lost motion. As has already been mentioned an increase of lost motion leads to a longer stroke and therefore it is safer to work without any lost motion until the behaviour of the pump has been observed. Moreover, dependent upon the work to be done relatively to the design of the pump, it may be found that better results are obtained without any lost motion. However if it is found that full stroke cannot be got after the pump has thoroughly settled down to work and is working at a suitable speed it will then be necessary to gradually give lost motion. The lost motion should ordinarily be adjusted symmetrically. Do not be in a hurry to fiddle about with the setting arrived at as above. Give the pump time to settle down and go easy. Make sure that both sides of the pump are alike in every way as far as possible, particularly as regards the packing of glands, etc.

13. As an alternative to the above procedure relating to the main valves the front covers of these valves may be removed, and the valves wedged temporarily in their central positions. The covers are then replaced and the valve rods adjusted to suit. Rods and covers are then again removed without altering the lengths of the rods, and then, after the valves have been freed, the parts may be finally assembled.

Some of the triple expansion pumps referred to have a separate steam stop valve on each side of the pump, and there are also valves whereby the exhausts from the two H.P. cylinders can be interconnected, and similarly as regards the exhausts from the two I.P. cylinders. The suitable adjustment of these various valves will often materially improve the running of the pump, but if the valves have been correctly set the best results are obtained by having all these valves wide open and controlling the steam supply by a single valve in the main supply pipe. The more modern pumps

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known to "Inspector" only have one single stop valve for the pump.

It is hoped that this Echo will enable anyone who has to do with any Worthington pumps of the types referred to, to take an intelligent interest in their working. It is not possible in a written note to deal completely with all difficulties that may arise, but a steam engine is a long suffering servant, and it is extraordinary how persistently a Worthington pumping engine will continue to push water notwithstanding adverse conditions. Nevertheless economical results can only be attained if the pump is kept in good order and is worked properly.

(*To be continued*).

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Major-General Sir John Hills, K.C.B., F.R.S.E.,
Late Royal Engineers.

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MEMOIR.

MAJOR-GENERAL SIR JOHN HILLS, K.C.B., F.R.S.E., ROYAL (LATE BOMBAY) ENGINEERS.

By COLONEL R. H. VETCH, C.B.

JACK HILLS, as he was generally called by his friends, was a member of a family well known in India for a long time back. His father, James Hills of Neechindapore in Bengal, son of Archibald Hills of Harestanes near Jedburgh and Ancrum in Roxburghshire, was one of the largest landowners and indigo planters in Bengal, and throughout a residence of over half a century gained the esteem and respect of both Europeans and natives in so large a degree that his name is still held in revered memory. He married a lady, half Italian and half French, Charlotte Mary Savi, daughter of John Angelo Savi of Elba, and granddaughter of General Corderan, commanding the French forces at Pondicherry. By her he had a family of six sons and four daughters :—

Archibald, the eldest son, was a cadet at the Hon. East India Company's Military Seminary at Addiscombe from 1850 to 1851, when he gave up the prospect of a military career in order to join his father in Bengal as a planter. He maintained the high reputation for probity, generosity and fairness and other qualities which had endeared his father to Europeans and natives alike. He was reckoned the best pigsticker of his day, and in consequence was especially invited to meet H.R.H. the Duke of Edinburgh at the Pigsticking Camp on the occasion of His Royal Highness's tour in India.

James, the second son, is better known under the double name Hills-Johnes, which he took on his marriage. He has had a distinguished career, passed his examination for Engineers but became first artilleryman of his term at Addiscombe, was commissioned in the Bengal Artillery on the 11th June, 1853, won the Victoria Cross during the Siege of Delhi and is now Lieut.-General Sir James Hills-Johnes, V.C., G.C.B., etc., late Royal Artillery, and Deputy Lieutenant and Justice of the Peace for Carmarthenshire. His services in the Mutiny, in Abyssinia, in Lushai and in Afghanistan are well known and are to be found in many books of reference.

John, the subject of this Memoir, was the third son.

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George Scott, the fourth son, was commissioned from Addiscombe in the Bengal Engineers on the 8th June, 1855. He retired as a colonel in March, 1887, having served in the Indian Mutiny (1857–8), the Bhutan Expedition (1864–5), and the Afghan Campaigns (1879–80). For many years he was employed in engineering the roads of Assam, especially those to Shillong, the headquarters of the new province of Assam. He distinguished himself in early life in active pursuits. He was a good billiard player and an excellent fencer and boxer. He died on the 11th May, 1892.

The two younger sons, Robert and Charles, were in business in Calcutta where they were well known in social and sporting circles.

It is a noteworthy fact that the three soldier sons of James Hills of Neechindepore were all mentioned in the same Honours Gazette (1881) for their services in Afghanistan: James was created a Knight Commander of the Bath, John a Companion of the Bath, and George was promoted to be a brevet lieutenant-colonel.

Of the daughters the eldest married Lieut.-General Jenkin Jones, Royal (Bombay) Engineers; the second married Colonel William George Cubitt, V.C., D.S.O., of the Indian Army; the third married Lewis Pugh Pugh of Abermaed, M.A. (Oxon.), J.P. and D.L., and some time M.P. for Cardiganshire, Barrister-at-Law, Advocate-General, Bengal, and Member of the Governor-General's Legislative Council in India; the youngest married Sir Griffith Humphrey Pugh Evans, K.C.I.E., of Lovesgrove, Wales, M.A. (Oxon.), Deputy Lieutenant and Justice of the Peace for Cardiganshire, Barrister-at-Law and for over 20 years Member of the Governor-General's Legislative Council in India.

JOHN HILLS, the third son, was born in his father's house at Neechindepore in Bengal on the 19th August, 1834. Sent home at an early age he was educated at the Edinburgh Academy and at the Edinburgh University, where he distinguished himself in mathematics and gained the Straton Gold Medal and Scholarship. He entered the Hon. East India Company's Military Seminary at Addiscombe on 6th August, 1852, and on leaving it was awarded the Sword of Honour, and received a commission as 2nd lieutenant in the Bombay Engineers on the 8th June, 1854.

After two years of professional instruction at the Royal Engineers Establishment at Chatham, John Hills went to India, arriving at Bombay in August, 1856. He was at once posted to the Bombay Sappers and Miners, and, having passed in Hindustani, etc., in December, was reported eligible for employment, and appointed, on 14th January, 1857, Assistant Field Engineer with the Second Division of the Persian Expeditionary Force, commanded by Lieut.-General Sir James Outram. Hills was present at the capture of Mohamra on the 26th March, receiving the medal and clasp.

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At the end of the campaign ill-health compelled him to go on furlough.

He was promoted to be lieutenant on the 5th November, 1857, and while at home was elected on the 21st March, 1859, a Fellow of the Royal Society of Edinburgh at the early age of 24 years, the youngest Fellow on record.

Returning to India Hills was, for a time, employed in the Public Works Department as Garrison Engineer at Fort William, Calcutta, but in January, 1862, he was transferred to Oude as Assistant to the Chief Engineer in that province. Promoted captain on the 1st September, 1863, he was sent two years later to Rajputana as Executive Engineer.

In 1867 Hills was selected for service with the force to be sent to Abyssinia under Major-General Sir Robert Napier, afterwards Field Marshal Lord Napier of Magdala. He was at first employed as Field Engineer at the camp which had been formed at Kumeyli at the foot of the mountains, to which place a railway was in course of construction from the base and port at Zula which was 10 miles away, in Annesley Bay on the Red Sea. At Kumeyli Camp he was chiefly occupied in obtaining a good water supply, by sinking wells and Norton tubes and in carrying out other engineering work at this large depôt. But his principal work was, a little later on, in the construction of roads. He was Field Engineer at Senafeh, a distance of over 50 miles from Kumeyli, the road rising in that length to a height of 7,400′, and having several bad defiles requiring skilful engineering. The road when completed to Senafeh had a breadth of 10′. Huge granite boulders had to be removed and in some parts it was necessary to cut the road out of the rock of the mountain side. Beyond Senafeh for some 37 miles to Addigerat a rough cart road was made but beyond Addigerat to Magdala the road was only a track passable for laden mules and elephants. Hills was mentioned in despatches and received the medal.

At the end of the campaign Hills returned to India and resumed duty in the Public Works Department as Executive Engineer at Lucknow. At the end of 1871 he was appointed Commandant of the Bombay Sappers and Miners at Kirkee and held the command for the next 12 years, bringing the Corps into a high state of efficiency. Meanwhile he was promoted major on the 5th July, 1872, lieut.-colonel on the 1st October, 1877, and brevet colonel on the 1st October, 1881.

During the Afghan War of 1879–80 and while still holding the post of Commandant of the Bombay Sappers and Miners, Hills was Commanding Royal Engineer of a division of the Kandahar Field Force in 1879–80 and of the South Afghanistan Field Force in 1881. He took part in the defence of Kandahar and distinguished himself on several occasions. For his services in this war he was mentioned

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in despatches, created a Companion of the Bath, Military Division, on the 22nd February, 1881, and received the medal.

After a furlough the next and last appointment which fell to Hills was that of Commanding Royal Engineer at headquarters of the Expeditionary Force to Burma in 1886–1887 when he saw more war service. He retired on the 31st December, 1887, with the honorary rank of Major-General. In May, 1900, Hills was promoted in the Order of the Bath to be a Knight Commander.

He was an all-round sportsman, a good cricketer, a powerful swimmer, a fine swordsman, an expert boxer and an excellent shot. Many tigers fell to his gun, it is said they numbered over one hundred. In 1900 he published an account of the work of *The Bombay Field Force in 1880*, with plans, in an octavo volume. He was a great lover of the horse and was a diligent student of that noble animal in its finest breeds for 30 years. He was engaged in correcting the proofs of an elaborate book entitled *The Points of a Racehorse*, when illness seized him. This work, published by Blackwood in 4to. form in an *edition de luxe* in 1903, gives the results of his experience and study. The book is dedicated to the Duke of Portland, and a fine plate of the late King Edward's Derby winner Persimon with His Majesty standing near forms the frontispiece. With a clear brain and a strong will he continued the correction of the proofs until within an hour or two of his death from heart failure, which took place at 50, Weymouth Street, London, on Wednesday, 18th June, 1902, after some weeks' illness. He was buried in the family vault at Kensal Green on the 21st.

Sir John Hills was never married. As his brother and two married sisters lived in Wales he was a frequent visitor to the principality where he made many friends and where some of his happiest days were passed. *The Carmarthen Journal* in an obituary notice of him says: "His powerful reasoning, his quiet sense of humour and gift of witty expression, his broad views, his kindly heart and ready sympathy brought a bright and invigorating element into his intercourse with friends."

The Secretary of the R.E. Institute has called my attention to the fact that Sir John Hills had the unique distinction of being the only officer of the Bombay Engineers who ever attained the honour of a Knight Commandership of the Order of the Bath, although the Bombay Corps had a larger proportion of Companions than either the Bengal or Madras Corps.

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TRANSCRIPT.

NEW ZEALAND FORCES.

(Extracts from a Report by Col. E. S. Heard, I.G.S., on the Training Camp at Tauherenikau, 7th January to 17th March, 1911).

THE training camp at Tauherenikau was instituted for the following purposes:—

1. To train a sufficient number of officers, destined for the New Zealand Staff Corps, to fill appointments on the Staff of the Defence Force, and as Adjutants of Territorial units.

To train the required number of N.C.O.'s as Sergeants-Major in charge of areas and Sergeants-Major of units.

Scheme of Instruction.—The scheme of work was of such a nature as to develop the powers of instruction in each individual, fit all ranks to take part in the training of the Territorial Forces, and carry out the necessary duties of registration and organization in the areas and area-groups.

Drill.—With this ideal in view, it was necessary to start everyone from the beginning, and give all ranks a thorough grounding in drill, progressively, from squad drill as recruits up to battalion drill and company training in the field. This progressive training was also carried out as regards mounted drill. Thus it was hoped that the officers and N.C.O.'s under instruction would be taught to be able in turn to instruct the recruits and trained soldiers of the Territorial units in their military duties.

This instruction in Infantry drill was handed over to the supervision of Capt. Hamilton, Grenadier Guards, Camp Adjutant, who was kindly lent to the Defence Department by His Excellency the Governor. As instructors under him, Capt. Hamilton had the assistance of the following N.C.O.'s of the Permanent Staff:—Staff Sergts.-Major Dovey, Cheater, Redmond, and Walker.

Progressive Training.—The scheme of training of all ranks was progressive—that is to say, everyone began at the beginning as recruits, no matter what their training or experience was in the past.

Squad Drill.—The officers and N.C.O.'s were divided into four Infantry squads, each under an instructor, and they began as recruits to be instructed in the correct manner of standing at attention, marching, turning,

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saluting, etc.; in short, how to carry themselves smartly with a properly soldierly bearing. All this preliminary part of the drill was without arms.

When they had sufficiently mastered the rudiments, and had in turn taken the part of an instructor, giving all the necessary explanations and words of command, they passed on to the next step, which is squad drill with arms. In this they were taught the proper method of handling their arms with precision and smartness both while marching and at the halt.

Communicating drill, which consists chiefly in the practice of using the voice properly in giving words of command, and in repeating the explanations and commands in drill, was made a special study, and was attended with good results. A great deal depends, in drill, on the manner in which a word of command is given. Some who have no proper command over their voice or manner of giving an order fail to produce smart movements in drill, while others who have the habit of command can do anything with their men. To obtain full value out of communicating drill the squad should be commanded from a considerable distance.

Company Drill.—After squad drill, the next step was company drill, and in this, as before, each individual took his turn in commanding squads, sections, half-companies, and the company, so that all should be familiar with every detail of company drill.

Battalion Drill.—When sufficient progress was made in company drill, battalion drill under the Adjutant or Commandant, was taken in hand. Owing to the lack of numbers, each company in the battalion was in single rank. The battalion was composed of six companies only. Officers took it in turn to perform the mounted duties of senior Major and Adjutant and of Commander of a Company, and occasionally one or other was called out to drill the battalion. The officers and N.C.O.'s had paid so much attention to their drill from the start that their movements in battalion drill, and the manner of handling their arms, left very little to be desired, and would have done credit to a battalion of Regulars. Their steadiness in the ranks was particularly noticeable.

Company Training.—Besides drill, company training in the field was undertaken. The officers and N.C.O.'s under training formed a company, at war strength, between 120 and 130 of all ranks. The training included attack and defence practices, advanced, flank, and rear guards, and outposts. As many as possible took it in turn to command squads, sections, half-companies, and the company. It must be noted that the officers and N.C.O.'s took their places together in the ranks, and were trained just as if they were ordinary privates in the company.

Field Engineering.—Instruction was also given in the construction of fieldworks under the supervision of Capt. Duigan, Headquarters Staff.

The time devoted to fieldworks was necessarily limited, but every officer and N.C.O. had a good grounding in the elementary principles of the work, and did his share of the actual digging, etc.

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The work carried out was mostly of a practical nature, and consisted of:—

Construction of a fire trench.
Loopholes.
Overhead cover.
Concealing trenches.
Cover lying down.
Cutting brushwood and clearing the foreground.
Tracing trenches.
Types of traverses for protection from enfilade and oblique fire.
Stone sangars.

The system of detailing working parties was thoroughly explained to all, and the principles of construction, effect of fire, handling tools, and siting trenches explained in a lecture.

I have no hesitation in saying that every officer and N.C.O. who was instructed in the above knows how to instruct his unit in the work carried out.

Mounted Duties.—All ranks, whether they formerly belonged to the mounted branches or not, were instructed in mounted drill. At first the instruction was given on foot, and the movements were thoroughly learnt in this manner. After this grounding was satisfactorily absorbed, the officers and N.C.O.'s were put through the drill on horses. At first the mounted squads learnt how to ride and handle their horses in the *manège,* as in riding schools. After this they carried on with troop and squadron drill, with and without arms. Paucity of horses and unsuitable ground prevented mounted work in the field being carried out, but as much training as possible in this direction was done on foot.

Capt. Spencer-Smith, Staff Officer to the G.O.C., undertook for a time the supervision of the mounted drill, assisted by Staff Sergts.-Major Dovey, Walker, and Redmond.

Thus all ranks, without distinction, were thoroughly instructed in infantry and mounted drill, so that each individually could undertake the duties of instructor in either branch, as Adjutants, Area Sergeants-Major, or Sergeants-Major of units.

Musketry.—In addition to drill and field training all ranks went through as thorough a course of musketry instruction as the time would admit, under the supervision of Major Hughes, Assistant Commandant, assisted by Staff Sergts.-Major Rose and Henderson. In this course it was intended to show how the recruit should be instructed, and for this purpose all those under instruction began at the beginning as recruits and were carried right through the course. They were shown the special points to observe in the instruction of recruits, and the method of conducting the standard tests. Great stress was laid on the care of arms, a very important matter, since in this country an alarming number of rifle-barrels are condemned every year through want of proper care on the part of those in possession of arms as Volunteers. Judging distance, also very important, was frequently practised. Great stress was also laid on the importance of fire discipline and control. The extreme usefulness of work on a miniature

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range was illustrated, and all the various methods of fire and specimens of targets were shown. Methods of testing the firers' errors in aiming, by grouping practices, and the errors in sighting of rifles also formed part of the instruction. As in the drills so in musketry, all ranks were practised in imparting instruction as to recruits, etc.

The whole course was very useful, and was ably carried out under Major Hughes and his assistants.

Examination.—Periodical examinations in drill, musketry, Commandant's lectures, and Adjutants' and N.C.O.'s duties produced very satisfactory results on the whole, testifying to the efficiency of the instruction given. The seniority of both officers and N.C.O.'s in passing out was determined in great measure by the results of these examinations.

Semaphore Signalling.—Semaphore signalling with flags was taught to all ranks, under the supervision of Capt. Duigan, Headquarter Staff, and all had to pass an examination in this branch. The training was very thorough, and the majority of officers and N.C.O.'s reached a very satisfactory standard of efficiency. Flag drill was not hurried, and the detail was grounded into all.

Many of the officers who were under instruction are proficient in Morse, which will be of great value to them in training the signallers of their units.

Physical Training.—Capt. R. O. Chesney supervised the instruction in physical training, which was undertaken by Corpl. Gallagher, R.N.Z.A. Certain exercises were selected from the Imperial Handbook on the subject, and all officers and N.C.O.'s have been given copies of those selected.

Lectures.—Frequent lectures were delivered by all the members of the Instructional Staff on various military subjects included in the course of instruction. Amongst these were lectures by the Commandant on attack, defence, protection, discipline, scouting, etc. Major Hughes gave a very useful and instructional series of lectures on musketry. Capt. Hamilton lectured on drill, duties of Adjutants, etc.; Capt. Duigan on fieldworks. Capt. Browne gave instruction in the fitting of saddlery. Capt. Reid, N.Z.V.C., on horses and horse-mastership. The latter is very important, and very much required in this country.

Special instruction was also given in the duties of Area Sergeants-Major.

Camp.—The camp was laid out by Capt. Browne, Headquarters Staff, Camp Quartermaster, and the excellent health of all ranks was due to his careful supervision, and the extreme cleanliness of the camp and its surroundings, which was always insisted upon.

Sanitation.—The latrines were on the pan and dry-earth system, and their contents were buried daily.

Soak-pits were dug for the reception of water used in washing utensils for cooking.

All refuse was burned in the incinerator, and empty tins and indestructible matter buried after passing through the incinerator.

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At intervals, behind the tents, receptacles were placed, into which scraps of paper and litter were thrown and afterwards burned. Thus the camp was kept clear of all rubbish.

Water Supply.—The water supply, duly tested and found pure, was obtained from a creek behind the camp, and pumped up to tanks by a hydraulic ram. A plentiful supply of water was thus obtained for all ranks, and shower-baths in sufficient quantities were erected.

Lighting.—All the mess marquees were lighted with acetylene gas laid on from a generator erected under the water-tank. This method of lighting was considered cleaner, safer, cheaper, and better than by oil-lamps. As a great deal of work, reading up manuals, etc., was done at night, it was necessary that the light should be good and adequate.

Horses.—For instruction in mounted duties 40 horses were purchased, and were placed under the care of Capt. Browne, Camp Quartermaster. These horses were kept in a paddock between the camp and the Tauherenikau River, and were looked after by a certain number of the R.N.Z.A. The Inspecting Veterinary Officer, Capt. Reid, in veterinary charge of camp, reported that their condition was very good, and showed great improvement since their purchase, which reflects credit on the care that was taken of them. Only one horse was cast, and this was sold after the camp was closed. The remainder were distributed among Area Sergeants-Major, as far as they would go. These N.C.O.'s will in some districts have to cover long distances in the execution of their duties, and therefore it is considered necessary that they should have a horse for the purpose.

Fatigues.—The necessary fatigue duties in camp were executed by a detachment of the R.N.Z.A. and a few civilians engaged for the purpose. These duties were carried out entirely satisfactorily, and all worked hard with commendable zeal and energy.

Situation of Camp.—The camp was situated on the south-east side of a belt of bush which stretched from behind the racecourse to the Tauherenikau River. The site was ideal, as the bush sheltered the camp very efficiently from the north-west wind, which frequently sweeps down from the hills with much violence. As stated above, the water supply was close behind the camp, and the Tauherenikau River close to the horse-paddock. This river was used for watering the horses, and a bathing-place was made in it for the use of the camp.

The ground on which the camp was pitched is part of the property of Mr. Quinton Donald, who very generously placed it at the disposal of the Defence Department for the purpose.

Daily Routine.—The daily routine of work in the camp was as follows:—Work commenced at 8.30 a.m., and went on till 1 p.m., with a break of half an hour from 10.30 a.m. till 11 a.m. After lunch, at 1 p.m., work recommenced at 2 p.m., and finished at 4.30 p.m. Saturday was a general holiday, and on Sunday a church parade was held in the morning.

Discipline.—Discipline in camp left nothing to be desired, and the

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smartness and soldierly bearing of all ranks is a matter for congratulation. The zeal and energy displayed by all officers and N.C.O.'s under instruction was extremely creditable. From first to last everyone showed a very commendable desire to learn all he could, and a great deal of work, both practical and theoretical, was done during hours supposed to be devoted to relaxation, and even late in the night. This soldierly spirit gives good promise for the future success of the Territorial Forces.

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Conclusion.—In conclusion, it was noticed that though the native-born of this country pick up field training and manœuvre very quickly indeed—a fact that is no doubt due to their outdoor life and habits of independence—drill and discipline does not come so easily to them. It is obvious, therefore, that a great deal of attention must be paid to the latter. At this school of instruction, as soon as they had been taught to drill, to skirmish, and to do as they were told, the rest came easily. In England, on the other hand, the soldier picks up drill and discipline quickly, but is slower in learning the principles of modern field training.

The camp was struck on the afternoon of the 17th March, and all ranks were despatched to their destinations by the same evening.

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NOTICES OF MAGAZINES.

Revista del Genio Civile.

July, 1911.

Electric Traction on Swedish Railways.—Sweden is one of the poorest countries in the world in coal which is only to be found in a very few places in the south, and consequently most of the coal used is imported. The State railways alone burn annually nearly £400,000 worth of English coal and those owned by private companies consume an almost equal amount. The country is however very rich in waterfalls, the power of which has hitherto remained idle, and for some time past the Government has been considering the introduction of electric traction on the railways. It was resolved to experiment with it in 1902, and during the years 1905, 1906, 1907 electric locomotives were employed on the Tonteboda-Värtan and Stockholm-Järfva lines. These tests aroused considerable interest all over Europe, as they represented the first attempt to use 20,000 volts on a live wire. The results were so successful that it was resolved to use electric traction on the Kiruna-Riksgränsen line, which carries very heavy traffic, connected principally with the transport of ores. The length of the line is 129 kilometres.

Steam traction, it is considered, will be unable in the future to cope with the traffic on this line, which is estimated to increase from 1,600,000 "tonnes" in 1908 to 3,200,000 in 1913 and 3,850,000 in 1918.

Were steam traction adhered to, it would be necessary to double the line in certain places, buy heavier engines, etc. With electric traction, on the other hand, the problem is solved by the fact that the trains will consist of 40 instead of 28 trucks—each carrying 35 tonnes—that the speed will be increased from 50 to 60 k.m. per hour instead of 40 as at present and further that this speed will only go down to 30 k.m. per hour on the maximum gradient ($\frac{1}{100}$) instead of 12.

The expense of changing to steam traction is £1,200.000, and the work will be carried out by a local firm and Siemens Schuckert of Berlin. The saving after transformation will amount to £2,344 per annum, to which figure must be added the money saved by not doubling the line.

It is interesting to note that this line is the most northerly of the whole world, being in all its length north of the Polar circle. From the point of view of defence against snowfalls, it can be divided into two parts; in the southern one no special measures are needed, but in the northern branch, which is 30 kilometres long, overhanging galleries of ferro-concrete are necessary in places to protect the line from avalanches, whilst in others a "scatterer" on the principle of centrifugal force is required.

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The power is supplied by the waterfall of Porjus 120 kilometres south of Kiruna; its flow is at present 23 cubic metres per second and this can be increased fivefold so as to supply an average horse-power of 65,000 (chevaux de force) per annum.

The water of Lake Porjus is led by means of a canal 45 square metres in section and 525 metres long into a distributing reservoir, which serves to equalize the level of the water. Thence five vertical pipes lead the water to the turbines in an underground machinery room, which can hold five turbines of 12,500 chevaux de force each. Three of them are coupled up to alternators (5,000 vols. periodicity 15) and feed the railway. The monophase current is boosted up to 80,000 volts at the switchboard, and thence goes on overhead lines to four sub-stations, where it is transformed back to 15,000 volts, at which potential it is fed direct to the contact wire over the line and thence to the engine.

The contact wire is supported on wooden posts 30 metres apart with hollow steel crosspieces. Arrangements are made to allow for expansion and contraction of the wire under varying conditions of temperature, and also to leave a little vertical play.

The engines for goods trains are in two identical parts, each of which contains a monophase motor which is coupled direct to the driving wheels. The engines are of the 0-6-0+0-6-0 type. The engines for passenger trains are of the 4-4-4 type, are in one part instead of two, and have only one motor which is coupled to the four centre driving wheels. The first type weighs 100, the second 70 "tonnes."

The goods trains consist of 40 trucks, or a total weight of 2,050 "tonnes"; their speed must not exceed 50 k.m. per hour or go below 30 k.m. per hour on the maximum gradients (1 in 100) or on the steepest curves (500 m. radius). The engines must be able to start on the ruling gradient and steepest curves and exert a tractive force of 31,200 kilos. The average annual run of goods engines will be 90,000 kilometres, that of the passenger train locomotives whose maximum velocity is restricted to 100 k.m. per hour, 100,000 k.m.

A. H. SCOTT.

REVUE MILITAIRE DES ARMÉES ÉTRANGÈRES.

July, 1911.

THE JAPANESE IMPERIAL MANŒUVRES OF 1910.—A long and detailed account of these manœuvres is given in the June and July numbers of this magazine; the following are extracts from the remarks on them:—

Two remarkable features were, firstly, the great detail in which they had been worked out by the general staff, and secondly, the intense spirit of the offensive displayed on every possible occasion. Although it is possibly a disadvantage to work out manœuvres too much in detail, it makes them all the better practice for the subordinate ranks. This seems to be the opinion of the Japanese staff, who consider that the

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higher commanders are best prepared for their duties by the study of military art and the carrying out of staff rides, and not by being given an entirely free hand on manœuvres.

As regards the offensive spirit, it was shown in every movement and in every order issued. Even if the order to retreat was given, it was stated that this was merely a preliminary to the attack. Troops were never to be found waiting to be attacked in entrenched positions, the main fight between two opponents almost invariably took place half-way between their positions.

The attacks were carried out with extreme vigour, at the double, in many cases at a fast run, and they invariably ended with a hand-to-hand engagement. There was but little use of entrenching tools in the attack, their use is contrary to the spirit of the Japanese regulations which state that they tend to tie the men too much to the ground; the main object is to get up to the enemy and decide the battle with the bayonet. The use of entrenching tools is only justifiable in cases where the attack is checked, so as to prevent the troops from being driven back.

Reserves were small in number, consisted mainly of infantry and engineers, with cavalry for those units not situated on the flank of an attack, and were invariably pushed home to the very last man. The use of heavy artillery to support the mountain or field artillery is considered normal—the proportion of heavy to field artillery being 1 to 5. The heavy artillery are armed with 4·5″ and 6″ howitzers and 4″ guns. They have eight-horse teams.

The advanced guards were composed of about one-third to one-quarter of the infantry of the whole force, as much cavalry as was available, two or three batteries per division, engineers, a medical corps detachment, and later on a section of the bridging train was added.

The fronts occupied by divisions, contrary to the practice of 1909, were restricted to 3·5 to 4 kilometres.

Great importance was attached to the adoption of a preliminary formation before the attack when some 2 to 3 kilometres from the enemy. This formation was generally taken up at night so that the offensive could be assumed at dawn.

The fire discipline of the troops was excellent.

The troops bore hardships without any signs of discontent, although they were made to bivouac out on two or three very cold nights, and in certain cases had to attack through ditches which wet them up to the waist.

By no means the least satisfactory feature of the manœuvres was the interest taken in them by the inhabitants of the districts in which they were held, and the great enthusiasm they evoked.

MILITARY NEWS OF DIVERS COUNTRIES:—

AUSTRO-HUNGARY.—*Re-organization of the Army.*—The terms of service to be adopted are 2 years with the colours except in the following cases:—(1). 3 years with the cavalry or horse artillery. (2). 4 years in the navy. (3). 1 year for specially qualified people. (4). 10 weeks instead of 8 for those people dispensed of service or for the "ersatz-reservists."

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After this period of colour service the troops will be disposed of as follows:—

Two-year men:—10 years with the reserve, which includes 4 periods of service or a total service of 14 weeks.

Three-year men:—7 years in the reserve, including 11 weeks training in 3 periods. They are exempted of 2 years in the Landsturm.

Five-year men:—5 years with the reserve, exemption of 5 years Landsturm service.

One-year men:—Mostly become reserve officers; undergo 4 subsequent training periods of 4 weeks each.

Ten-week men:—12 years reserve service, 3 periods of training of 4 weeks each.

The increase of the peace strength of the army from 103,000 to 159,500 men will be spread over 3 years, at the end of which time the forces will be divided as follows:—Austria 91,313 men, Hungary 68,187. Of these, 134,500 will be 2-year, 19,000 3-year and 6,000 4-year men. This strength is liable to be modified after 12 years.

The privilege of serving for one year only, has been restricted to those who:—(1) Have studied in a secondary school; and (2) Have undergone the necessary government examination to qualify for this privilege. (3) To schoolmasters, or to university students.

Those one-year men who are not at the end of their time considered fit to become reserve officers will be given lower rank. One-year volunteers need not serve at their own expense except in the cavalry, horse artillery or train.

The choice by ballot of the people who become "ersatz-reservists" is suppressed, they will be chosen for reasons of health, family, or professional interest.

Only students in Holy Orders, landed proprietors who till their own lands, and supporters of families are dispensed from military service.

The Honved is also to be reorganized:—

(1). It will be increased from 94 to 97 battalions, and each regiment will be given a second machine-gun detachment. The strength of a company will be 80 instead of 50 men. (2). The strength of the squadrons will be raised from 63 to 100 men; each regiment of hussards will be given a machine-gun detachment, and the 10 cavalry regiments will be organized into two divisions. (3). Each of the 8 infantry divisions will be given an artillery brigade of 8 guns or howitzers, and a horse artillery brigade of 3 batteries will be allotted to each cavalry division. (4). The peace strength of the Honved will be increased yearly so as to reach 25,000 in 3 years.

Supply of Ammunition and Bayonets to the Cavalry.—The cavalry are in future to carry 80 rounds instead of 50. Of these 30 are to be carried on the man, and 50 on the horse. A horse is also allotted to each squadron to carry ammunition. A short bayonet is shortly to be issued to the cavalry.

Steps are being taken to instruct officers of the Hungarian Army in German, so that they may follow with full advantage the instruction given in the German-speaking military establishments, viz. the Staff College,

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and School of Construction, of telegraphy. Subaltern officers must also be perfectly acquainted with the language of the regiment with which they are serving; this knowledge is to be tested by severe examinations.

Combined Manœuvres of the Army and Fleet in 1911.—These are to take place this year in Dalmatia, the land forces consisting of a brigade of mountain troops with some cavalry and mountain artillery, and the sea ones of 6 battleships, 7 cruisers, 18 torpedo boat destroyers, 12 torpedo boats and 12 submarines. These manœuvres will not consist merely of embarking and disembarking troops, the general idea being that a part of the Istrian coast is being attacked by a portion of the fleet, which is defended by the land forces and the remainder of the fleet. Similar manœuvres have not taken place since 1906.

GERMANY.—27,278 horses were submitted to the remount commissions in 1909, of which 14,047, or somewhat over 50 per cent. were purchased. Their average price was 1,331 francs, an increase on the prices of the two previous years. The highest price paid was 2,125 and the lowest 1,000 francs.

The report issued at the end of 1910, showing the age of officers, calls forth the remark that the time spent in the ranks of captain, major and divisional general has increased since 1909. The promotion is very slow at the present moment, especially in the infantry where officers are often promoted as supernumeraries and do not get the pay of their rank till two years later. This is not so marked in the cavalry and engineers. The youngest brigadier is 52 years old—the oldest 57. The divisional generals average 54 or 59, the difference in age being accounted for by the fact that officers who have served on the staff are promoted more rapidly than regimental officers. At the present rate of promotion it is impossible for the senior majors ever to reach the rank of general, and even the juniors will not become colonels before they are 53 years old. The question of quickening the promotion of officers is at present being gone into in Germany.

SPAIN.—*Regulations on Aviation in the Army.*—Regulations have recently been issued on the training of officers as aviators. The aircraft are all under the direction of the Engineer Experimental Committee. The aerodrome is under the command of a field officer of engineers, who will record the experiments carried out and the flights made by each officer. The civilian professors come from the firms which supply the machines.

The conditions to be fulfilled by would-be aeronauts before selection are:—(1). They must be pilots of spherical balloons in the corps of engineers. (2). They must have some theoretical knowledge of aviation, and a practical and theoretical knowledge of motors. (3). They must be accustomed to drive fast motor cars, or to ride motor cycles.

The qualifications for the certificate as pilot are:—(1). To make two flights of over 5 kilometres in the aerodrome, and to "ride the machine on either rein." (2). To be able to raise their machine to a height of at least 50 metres: this can be tested either in one of the first two flights or in a third one.

As soon as there are sufficient pilots, they will be employed to replace the present civilian professors.

ROUMANIA.—A new rank has just been created in the army, viz. that of

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army corps commander. This is at present, however, merely a rank with no corresponding appointment.

RUSSIA.—It has been decided that 12 officer aviators will take part this year in the manœuvres. Russia at present possesses 30 flying machines, and 12 new ones are daily expected.

The Army Estimates.—There is a large increase in the 1911 estimates: the chief causes being: New barracks, 5,000,000 roubles; calling out of reservists for training, 5,000,000 roubles; transformation of the field artillery, 3,000,000 roubles.

22,028 roubles are devoted to the Aircraft Section and the Aeronautical Experimental Committee; 25,000 roubles for the organization of aviation tests; and 6,506 roubles for the upkeep of the new wireless telegraph stations.

A. H. SCOTT.

RIVISTA DI ARTIGLIERIA E GENIO.

June, 1911.

DETAILS OF PERMANENT FORTIFICATION.—In a long and exhaustive article Lieut.-Colonel Zunino of the Engineers enters very fully into the above subject, dividing it into ten parts, viz.:—(I.) On the installation of Gardner's mitrailleuses with vertical loopholes, or in barbette and with horizontal loopholes. (II.) On a concealed metallic caponier for resisting the fragments of artillery projectiles. (III.) On movable shields for protecting windows from projectiles. (IV.) On metal covers to be used in peace time for preserving armoured towers and turrets from the effects of the weather. (V.) On camp beds to fold up against the ramparts. (VI.) On drawbridges, and armoured gates of ingress capable of resisting the fragments of projectiles. (VII.) On a special arrangement of chains for regulating the various positions of drawbridges. (VIII.) On armoured shields with loopholes for protection of windows from artillery projectiles, and from rifle fire. (IX.) On an indirect method of access to an unguarded work in time of peace, when the drawbridge is raised. (X.) On a method of preserving caves or underground works from the dropping of water from the roof. Considerations on the action of frost on mortar, and on the plaster at the base of cemented works.

All these protective methods are very fully described with excellent plans, diagrams and photographs.

VISUAL SIGNALLING IN THE GERMAN COLONIES IN AFRICA.—The German periodical *Kriegstechnische Zeitschrift für Offiziere aller Waffen* of March and April, 1911, publishes a valuable article by Hermann Thurn on the employment of visual signalling. It is divided into two parts. The first treats of the use of visual signalling at manœuvres, and requires no particular comment as this branch of the service in the German Army has been fully developed and leaves nothing to be desired.

The second part is of an essentially descriptive character and contains an account of the evolution of visual signalling from its commencement in Africa up to the present time. The first record of the use of visual signalling in the German colony dates from the year 1901 in the pro-

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tectorate of Eastern Africa. At that time a department of instruction in signalling was formed at Dar-es-Salam with one officer and two European non-commissioned officers, with a certain number of natives who could read and write; this detachment made use of the heliograph exclusively. In the exercises which took place in the hinterland of Kilva and Kilimanjaro the detachment took part for the first time and initiated the sending of telegraphic messages by means of the heliograph up to a distance of 90 k.m.; these experiments at first were not successful owing to the mist, and the masses of vapour which collected after the rainy season. It was not until the summer of the same year that they succeeded in overcoming a distance of 200 k.m. joining the station of Kilimatinde on the Dar-es-Salam–Tabora road with the military post of Mikalamo in Issansu.

In 1904 and 1905 the experiments assumed greater proportions, and a network of stations for extensive visual signalling was established. Moreover a line was established from Kilimatinde in a north-east direction towards Ussandam (67 k.m.), and the first intermediate station was established at the military post of Kwa Mtoro. From Ussandam other lines were determined towards the north-east to Turu (37 k.m.) to Ijambi (53 k.m.) and to Mkalama-Issansu (37 k.m.). The trials on these lines lasted for two and a-half months. The signalling on this network of lines worked very well and was only impeded for short periods during the rainy season. The stations were at considerable altitudes, 1,200, 1,450 and 1,850 m. respectively but the system was sensibly impeded by clouds, as had happened at the mountains of Kilimanjaro and Meru at inferior heights of 1,400 m. At distances beyond 80 k.m. they succeeded, in favourable conditions of the atmosphere, in establishing communication, but were not able to guarantee the security of the service.

In the year 1904 a section for visual signalling was attached to the Commission for the delimitation of the Anglo-German boundary between the Lake Victoria-Nyanza and Kilimanjaro. The heliographs on this occasion besides being employed for the transmission of messages were also used to render visible very distant trigonometrical points, and were of great assistance to the Commission.

From December, 1904, to February, 1905, the signalling detachment established communication between Muansa on the south bank of Lake Victoria, and the military posts of Schirati on the east bank, and Ikoma in the plain of Massai. This communication was rendered necessary owing to the frequent raids of the Massai. The communication by heliograph was also of assistance as a guard at Muansa, and to the before-mentioned posts in case of alarm. The distances between Muansa and the two posts at Schirati and Ikoma were 192 and 196 k.m. respectively. The signalling line devolved from Muansa over the Gulf Speke, towards the mountain Kiruwiru (86 k.m.) and from this mountain proceeded for 67 k.m. towards the mountain Tschamliho, from which it separated into two lines, the first to the north-west, for 53 k.m. towards the mountain Ujamgirodi, and from this for 46 k.m. towards Schirati; the second line ran to the south-east from Tschamliho for 61 k.m. towards Ikoma. At the same time communication was established between Ikoma and the Orgoss posts situated 56 k.m. to the south-east.

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The network described above worked regularly from February to the end of May. Commencing in June, and during the dry season, the Gulf Speke remained covered with mist so dense that the lines Muansa-Kiruwiru and Kiruwiru-Tschamliho, which were above the water of Lake Nyanza, were interrupted. On the contrary the lines from Tschamliho that communicated respectively with Schirati and Ikoma, which were over the land, remained permanently in action.

Later on in January, 1907, when the political situation in the Portuguese Protectorate of East Africa became complicated and rendered the permanent location of colonial troops in Kionza necessary, this point was joined heliographically with the last station, distant 61 k.m. from the permanent telegraph line in the south at Mikindani. Afterwards the signalling detachment established communication by heliograph between Lindi and the posts of Ssassavara, distant 350 k.m., with four intermediate stations, and this also worked well during the rainy season as on five days only in the middle of the month were the transmission of messages impossible. This result was the more satisfactory when one reflects that the permanent electric telegraph lines were frequently interrupted, not only owing to atmospheric influences but also to damage caused by vegetation and animals.

To ensure a quick and accurate visual signalling service in case of necessity, the heliograph detachments should fix at once the more important lines of communication, the points at which the transmission of messages can be guaranteed and which are adapted to a permanent occupation. The indispensable conditions for the last are an ample supply of drinking water and means of subsistence, and reliance on the good faith of the inhabitants.

The heliographs actually supplied with lenses 15 c.m. in diameter, gave an intensity of light such that a detachment provided with three apparata could always maintain communication up to 150 k.m. in distance. The signalling apparatus was transported on the backs of horses and mules and presented no little difficulty, especially with the metallic oxygen receptacles, which were heavy. At all the stations a small detachment of from two to six men was stationed at each post, and signallers frequently had to remain alone for several months at altitudes, exposed to all the inclemency of the weather, deprived of succour, and in danger of attacks from the natives, having to trust to their own resources, with scarce provisions, little water, and without sanitary appliances. Many of the telegraphists were prostrated by nervous eye complaints, and the want of change made rest necessary which they could not obtain.

The station at Falkenhorst for 10 consecutive days remained completely blocked, and the men, suffering from heat and thirst, were finally reduced to using rum instead of water for cooking purposes, whilst one of the company held out by the apparatus so that the service might not be interrupted.

The network of signalling during the operations in South-West Africa was greatly extended. The lines Windhuk-Keetmanshoop-Ramansdrift covered a distance of 800 k.m. or about that of Berlin to Milan. The complete network in July, 1905, extended to 2,500 k.m.

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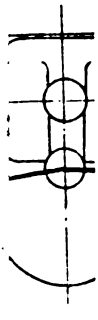

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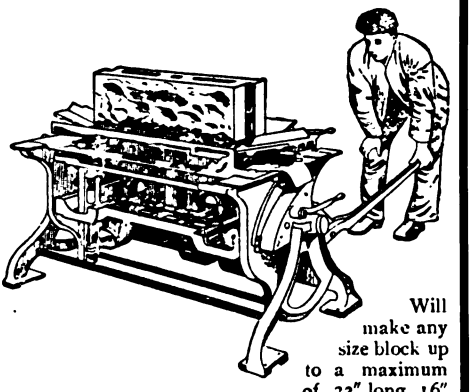

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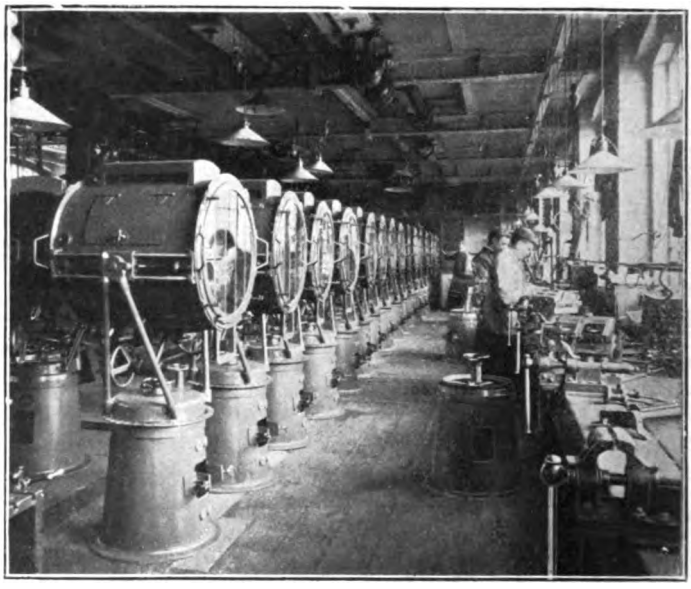

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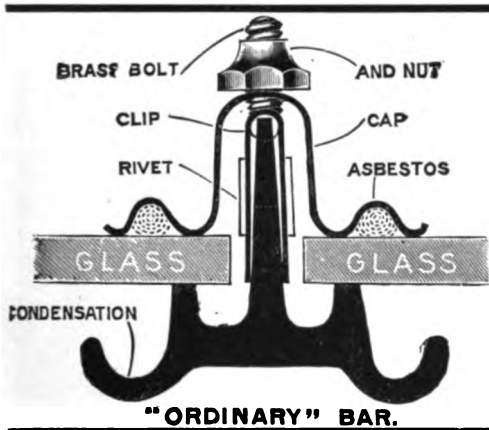

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BRIGADE TRAINING.

By MAJOR A. F. SARGEAUNT, R.E.

MY excuse for again alluding to Brigade Training is that it is chiefly during training that R.E. are brought into contact with the other arms, and the latter form their opinions by what they see of the R.E. during this period and by the versatility of the R.E. to adapt themselves to the varying circumstances of training and manœuvres.

Some months before the 12th Company, R.E., was to be attached for a fortnight to the 16th Infantry Brigade for brigade training, the O.C. Company had lent the Brigadier and Brigade-Major a copy of General Heath's lecture delivered to the Aldershot Military Society last winter (*vide R.E. Journal*, August, 1911), and the Brigadier was as keen to make use of the R.E. as the R.E. were to be used. Consequently when the programme of work for the fortnight was drawn up, a copy was sent to the O.C. 12th Company and he was asked to make suggestions as to how the R.E. should be used on various occasions.

It was a great gain that much of the manœuvre area was open scrub land where the owners and tenants placed no restrictions on turning up the ground so long as trenches, etc., were afterwards filled in ; so that whereas as a rule the R.E. can do but little actual work when training with other arms, this year much of the work was of a practical nature.

Before the actual manœuvring, the preparation of the camping area gave some scope for R.E. work. A small stream 20′ wide ran along one side of the camp (pitched in a 30-acre field) and a dam was formed in this with the aid of a tarpaulin to make a bathing pool, a well was dug 18′ deep for drinking water, washing facilities arranged, cooking shelters erected, approaches made from the road into camp, communications improved, a market inaugurated, etc. Subsequently Colonel Rose, of The Black Watch, who is an ardent water diviner located water in a small area near the Officers' Mess, and he won a wager by water being found at a depth of 15′ by means of a Norton tube well.

It is now proposed to take some of the days and show what part the R.E. played, but the days selected were not necessarily consecutive.

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1st Day.—Mountain warfare against savage tribes. The force had to march down a long narrow wooded gorge, and to enable men and animals to pass freely the track required considerable improvement; gaps had to be made in walls, a path cut through a belt of tall undergrowth, two causeways made across a river and a bridge built over a tributary stream.

2nd Day.—Attack against a flagged enemy. The ground was too open for the Sappers to be of any use during the attack, as when bullets are absent and the enemy a flagged one an attack knows no check of any duration; but, as soon as the position was captured the R.E. officers rode forward and made a reconnaissance of the position with a view to strengthening it against a counter-attack. Having viewed the ground himself and collected the reports and sketches from the subalterns, the O.C. Company submitted his report and proposals to the Brigadier.

3rd Day.—Strengthening a position for defence. Acting on the report of the previous day the Brigadier divided the position into four sections, and each battalion was allotted to a section and given four hours in which to dig trenches and generally strengthen the section allotted to it. A section of the field company was allotted to each section of the defence to assist and advise the infantry. The ground was hard and stony and in one place rock was found 18" below the surface; an urgent message was sent from O.C. Section for explosives but of course they did not exist. The Brigadier was strong on the point that everything attempted was to be completed at the end of the four hours, that is to say that the work was to be undertaken according to tools and material available, and all parapets, banks, etc., were to be bullet proof.

4th Day.—A retirement from the position strengthened on the previous day. The Brigadier, owing to the enemy being reinforced, decided to retire to a position selected in rear; this position consisted chiefly of a line of banks and walls. As soon as the order to commence the retirement was given, the Field Company was taken back to the second position and with pick and shovel strengthened it and improved the lateral communications. When the retiring troops had reached this second position the company was again assembled and was on its way to yet a third position when the "cease fire" sounded.

5th and 6th Days.—Outposts for 24 hours. One battalion was allotted to each section of the outpost line (comprising two sections), and ½ Field Company was allotted to each section to assist in strengthening the line and to advise as to method of defence, etc. It is questionable whether R.E. can be of any practical use in an outpost line by night, and having done their work in assisting and advising the Infantry their place would seem to be with the Reserve

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till required for other work, but the Brigadier was desirous of keeping some of the Sappers with the outposts by night so that they would be at hand if wanted; two sections of the company therefore remained out, and the other two sections joined the Reserve.

7th Day.—Attack and change of direction. As before there was not much scope for R.E. work during the attack, but the Sappers and tool carts followed the firing line as close as possible under cover, so that they might be at hand and ready for work after the final assault.

On two other days ½ company R.E. was attached to either side for tactical field days.

But a mere recital of facts is not of much use unless lessons are to be deduced from them, and during this training several lessons were learnt or former impressions emphasized, namely :—

If R.E. are to take their proper place with other arms and if they are to be used to the best advantage it is essential that the O.C. R.E. should by his actions show the G.O.C. that he is worthy of being taken into his confidence. In the present case the R.E. encamped alongside the Brigade Headquarters, and this is a decided advantage in cases where the R.E. are not represented on the staff of Headquarters. But it is not only in camp, but in the field too, that the O.C. R.E. must be constantly at the G.O.C.'s side so that he can at once send orders or information to the R.E. as the situation changes or develops. An O.C. of a Field Company has in addition to the mounted N.C.O.'s, who will probably be required with the mounted section, a mounted trumpeter who can well be used in carrying orders and messages.

Secondly, it is valuable experience for R.E. to train with other arms as by this means all learn each other's capabilities and limitations; and even in such matters as march discipline (for which on one occasion the 12th Company was specially commended by the Brigadier at the daily conference) the R.E. learn to take their place in a fighting column.

Again, it is very necessary for all ranks to be imbued with the spirit of initiative ; N.C.O.'s and sappers must not wait for orders, or to be interrogated, but must themselves suggest where a trench should be sited or how a bank should be strengthened. This can only be done thoroughly if N.C.O.'s and men understand the scheme and what is taking place ; and, if the O.C. R.E. is in touch with Headquarters he will be able to give early explanation of the G.O.C.'s intention, what it is proposed to do, and what are the dispositions of the other arms. This spirit of initiative is an important factor, and the other arms expect to find it in the R.E.

Lastly, seeing how much is expected of R.E. it is essential that the Royal Engineer should be a man whose technical qualifications are of the highest, and one who is also educationally fitted for the responsibilities which he must be prepared to take.

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It was gratifying to find on the conclusion of the training that the efforts of the R.E. to make the training a success so far as they were concerned had met with the approval of the Brigadier who wrote conveying his appreciation of all the work the R.E. did, and hoping that the tactical aspirations of the R.E. as regards R.E. work had been more fully satisfied than in the previous year. This measure of success was only achieved because the Brigade Staff realized that the R.E. were there to be used, and gave them every opportunity of working in conjunction with the infantry and artillery.

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HISTORICAL DOCUMENTS OF MAJOR-GENERAL SIR J. T. JONES, BART., K.C.B., R.E.

(*Continued*).

In last month's *R.E. Journal* three papers, referring to the year 1809, were reproduced, and in the present issue a further instalment is given consisting of Capt. Squire's report on the first assault on Badajos in 1811, as well as some letters and memoranda from Sir R. Fletcher on engineering details of the siege.

The first memorandum by Sir R. Fletcher speaks only of "a particular service," but, as it was docketed with other papers referring to the Siege, it most probably refers to it.

(1). *Memorandum by Sir R. Fletcher.*

VILLA FORMOSA,
10th April, 1811.

Return of Ordnance contained in the accompanying list from Elvas, which it may be necessary to employ for a particular service, and which should therefore be examined under the direction of the Commanding Officer of Artillery with the Ammunition and Stores of every description belonging to it :—

GUNS.

24 Prs. (Brass)	30

Mortars—(Brass).

13 Inches...	2
12 Inch	4
11 Inches...	1
3 Inch	6

Howitzers.

9 Inches	4
7 Inches	6
7 Inches	4

Ammunition.

To be in readiness—400 rounds for Gun and 200 for each Howitzer or Mortar with the proper proportion of grape and case shot for the two first descriptions of Ordnance.

(Sd.) RICHARD FLETCHER,
Lt.-Colonel, Commd. Rl. Engineers.

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(2). *Letter from Lt.-Col. H. Hardinge to Capt. Squire, R.E.*

ABOUNA,
April 12th, 1811.

MY DEAR SIR,

The Marshal requests you to draw out an estimate of all that may be requisite to undertake the Siege of Badajos. It is very desirable to commence against the place with as little delay as possible—

Elvas cannot probably furnish much more than Guns, Powder and Shot of which Major Dickson can probably give you information—He begs you will consider and specify the means which you conceive the country on both banks of the Guadiana can supply in Gabions, Fascines, Timber for Platforms, etc., which the Marshal imagines can be prepared in the neighbourhood of the place, and that the Militia and Country people can make them, the Dimensions or models being given. Sandbags it will probably be difficult to obtain in sufficient quantities. Intrenching Tools will be a very principal want, but the Marshal begs your attention to the Working Tools made use of by the Country people, and whether with those from Elvas or now in your possession, it may not be possible to undertake the Siege of the Place applying to this object the means of every description which Elvas, the Army, and the Country can provide—Should the Country Tools be considered applicable, you will be so good as to state the nature and numbers required and the other articles likely to be procured in the country and which the Marshal will endeavour to obtain—

He desires me to remind you (although it will not have escaped your attention,) that the repaired breach may not be very perfect, and that you may judge it adviseable to conduct your approaches by those recently made and since filled up by the Enemy and which may render the inefficiency of the Tools less a matter of importance than it would otherwise be.

He also desires that you will take into consideration the circumstance of the Strength of the Enemy's garrison which he has reason to suppose does not exceed 1,500 men.

Believe me very truly,
Yours,
(Sd.) H. HARDINGE,
Lt.-Col.

CAPT. SQUIRE, Royl. Engrs., etc.

(3). *From Lt.-Col. H. Hardinge to Capt. Squire, R.E.*

April 11th.

MY DEAR SIR,

The Marshal begs you to inform Major Dickson that he wishes him to remain with you for the present.

He has ordered 160 men of the Portalegre Militia to work at the trenches, these are the shy gentlemen who would not show their faces in the Defence of Campo Maior. Don't spare them in work for it is to be a punishment.

H. HARDINGE.

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(4). *From Capt. Squire, R.E., to Lt.-Col. H. Hardinge.*

April 11th.

MY DEAR COLONEL,

I have just received your note of this day. I hope and trust the Marshal may be induced to alter his determination with respect to the Portalegre Militia. We shall need a working party of 200 men to be relieved every 4 hours and, as for our intended operation our *travailleurs* ought to be good men and true, I entreat the Marshal that our working parties may be taken from the troops which remain before Olivença. Besides we shall certainly want 20 intelligent masons and 20 good miners. Without such assistance I fear our operations will neither be of advantage to the service, nor do any credit to ourselves. Besides good superintending officers are indispensible. I know from experience how little I can depend upon the officers of Militia. Pray represent the subject to the Marshal for your note has thrown me into such a fit of despair that I see no relief for me unless certain efficient means are placed at my disposal.

I had fondly hoped that for our intended operations we should have had some of the best English soldiers in the Army. I shall do whatever I am ordered but in my present situation I think it right to speak the truth. Our Department has no means within itself and unless I am permitted to select such means as I think necessary to our success, I foresee great difficulties, great delay and consequently great discredit.

Believe me
Ever yours,
J. SQUIRE.

(6). *Memorandum from Capt. Squire, R.E.*

OLIVENÇA, *April 18th*, 1811.

SIR,

I request you will submit to his excellency Marshal Beresford the propriety of forming a Corps of Artificers (amounting to 100 men) from the British Regt. of Line, who should be attached to the Engineer Dept. during the attack on Badajoz.

Viz: Miners—50; Carpenters—20; Masons and Bricklayers—24; Smiths—6. Total—100.

Such men as have been employed in the lines in front of Lisbon will be best calculated for this service.

I should recommend that the men be regularly paid at the same rate as Military Artificers employed in England.

I have the honor to be
Your very obedient servant,
JOHN SQUIRE.

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(7). *Memorandum of Instructions for the Siege issued by the Brigade Major, R.E.*

Orders and Instructions for the Guidance of the Engineers at the Siege of Badajos.

Arrangement and Distribution of Officers and Men.

Capt. Squire is to have the general superintendence of the attack under the orders of the Commanding Engineer.

The other Engineers and Assistant Engineers are brigaded as follows:—

1st Brigade.
Capt. Patton.
2nd Capt. Dickinson.
Lieut. Thompson.
Lieut. Whitford, Asst. Engineer.

2nd Brigade.
Capt. Ross.
Lieut. Emmett.
Lieut. Melville.
Lieut. Medlicott, Asst.

3rd Brigade.
Capt. By.
Lieut. Forster.
Lieut. Davey, Assist.

4th Brigade.
Capt. Macleod.
Lieut. Stanway.
Lieut. McPherson, Asst.

5th Brigade.
Capt. Boteler.
Lieut. Reid.
Ensign Leslie, Asst.

6th Brigade.
Capt. Mulcaster.
Capt. Mienite.
Lieut. Wright.
Lieut. Goldfinch.

7th Brigade.
Capt. Wedekind.
Lieut. Hunt.
Lieut. ——, Asst.

To each Brigade of Officers is attached 1 N.C. Officer and 14 Privates Mechanics and 1 N.C. Officer and 5 Privates Miners—the former are to be considered as an integral part of the Brigade, and will invariably take the same tour of Duty as the Officers, but the Miners are to be considered as separate bodies attached to the Brigades and will occasionally be ordered to any duty when the rockiness of the Soil in any particular operation may render necessary their united exertions—

There are six Brigades of Carpenters of 8 each for the purpose of laying Platforms and constructing Magazines and their duty will be regulated as the work requires them and by an Order from the Commanding Engineer.—

To the Clerk of Stores at the Park are attached 2 N.C. Officers and 6 Privates R.M. Artificers, of whom 1 N.C. Officer and 3 Privates will be constantly on duty.

Method of carrying on the Duty.

The Duty of the trenches will be done by Brigades—

The Hours of relief being 4 p.m. Midnight and 8 a.m. The tour of Duty of the Brigade will be given out in daily orders.

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On no account is the officer commanding a Brigade to withdraw from the Trenches till the officer relieving him expresses himself fully to understand the work in Progress, and he is to take particular care to explain to the relieving officer any Verbal directions received during the time of his being on duty.

The Workmen are to be so arranged that 30 men shall occupy a line of 40 yards, *i.e.* the men shall be four feet apart, and in that proportion it is expected that in the first relief or 8 hours work a Trench shall be sunk at least 3-6 (ft. in.) deep by 4 feet in width.— Distribution of Workmen in the Trenches.

The first parallel when completed will be 12 feet wide at the bottom and 3-6 (ft. in.) below the level of the Natural ground—of which the full depth and 4 feet in width is to be excavated the first night.— Parallels.

Tracing Fascines are to be laid to mark out the direction of the parallels, and the ground is to be opened two feet behind them and the earth to be thrown in their front in order to leave the space for the Banquette. The ascent to the Banquette will in the 1st instance be made as circumstances will admit of but is afterwards to be made with one step one foot in breadth.

The inclination of the Superior Slope of the Parapet when finished not to be greater than is absolutely necessary to give it a proper command of the ground in its front.—This is particularly to be attended to, that it may be completely shot proof.—

Approaches when completed are to be 10 feet wide at the Bottom, and 3-6 (ft. In.) deep below the Natural level of the Ground and each return is to be prolonged 15 feet towards the Rear. Approaches.

In the construction of batteries when it is feasible, two Parties are to be employed, one in the Ditch to throw the earth inwards, the other in the inside to lower the Terreplein 2 feet and to throw the earth outwards. Batteries.

All Batteries thrown up within 800 yards of the place are to have a thickness of Parapet at the top of 18 feet, and in no situation are to be made with a less thickness at the top than 15 feet. The Superior Slope will *rise outwards* and be made one twelfth the thickness—

The Parapets of all Batteries on the same level with the place to be made 7 ft. 6 in. high, those on a lower level 8 feet high, and in no situation are they to be made less than 7 feet—

It is intended that the interior of the Batteries should be supported with Gabions, and they have been made 3 ft. 6 inch in height, so that two Gabions by the addition of more or less earth to Cover them will in all situations form the height of the Parapet—all fascine work to have a slope of one foot in 3 feet, and Gabions of one sixth.—

The Embrazures are to be laid out 22 feet from centre to centre when no obstacle to this being so shall present itself—Embrazures for guns to be made 2 feet wide at bottom on the inside: the slope to Embrazures.

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the cheeks to be one third unless they are to be retained by Gabions in which case it is to be only $\frac{1}{8}$.

Embrazures for Howitzers to be made 2 ft. 4 in. wide at bottom on the inside and the sill to be sloped upwards with the same inclination as the Parapet—For the height of the Genouilliere no rule can be given as the gun carriages are of various heights—

Platforms. The Platforms are to be made 12 feet wide at the Tail, 8 feet wide in front, and 12 feet long with four sleepers, and they are to be laid down with an inclination $\frac{3}{4}$ of an inch in a foot.

Traverses. Splinter-proof Traverses are to be made in all the Batteries between every second Gun or Howitzer, their construction to be as follows:—12 feet long, 6 feet high and 6 feet thick at top, placed at right angles to the Parapet and two feet distance from it at the Bottom:—

Magazines. The Magazines are to be made of the Splinter-proof construction, to be placed behind a good traverse or some secure cover—The Splinter-proof Timbers are cut of the following Dimensions:—12 feet long, and from 7 to 10 inches in diameter, and they are to be placed at an angle making the base half of the height—

The communications from the Magazines to the Batteries to be made 4 feet deep and 6 feet wide—

By order of the Commanding Engineer,
(Sd.) JOHN T. JONES,
Brigade Major.

To CAPT. SQUIRE, Rl. Engineers.

(5). *Memorandum from Sir Richard Fletcher.*

ELVAS,
7th May, 1811.

Memorandum.

Capt. Squire is charged with the direction of the attack against Fort St. Christoval—

As soon as Badajos shall be invested on the right bank of the River, he will choose a convenient Situation to form the Depôt of Stores—

He will select a favourable spot for the construction of a Battery of three Guns and two Howitzers to ruin the defences of St. Christoval and the parts of the Scarp Wall most exposed—This Battery should if possible be so placed as to enfilade the old wall of the East front of the body of the Place, without being itself exposed to the fire of two heavy Batteries commanding the Gorge of the Fort.—

If this situation should be favourable for the eight pieces of Artillery appropriated for the right bank of the River, and should not only enfilade the east front of the main work but command the North Wall near the angle, it would seem desirable to place the whole in one Battery—Should this not be the case another spot will be chosen to assist in these objects, and if practicable the second Battery should go forward at the same time with the first—

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Such Parallels as appear necessary for a first covering party and proper trenches of communication will of course be added.

The Enemy having quitted St. Christoval, Capt. Squire will either by occupying the work itself, or by sinking cover for a body of men, Endeavour to prevent its being re-occupied but in doing this care must be taken to avoid an enfilade fire from the *Tête-de-pont*—

If a Battery for two or three Field-Pieces could be thrown up in some Covered Situation to enfilade the bridge it might of course tend materially to keep the Enemy within the body of the place—

(8). *Letter from Capt. Squire, R.E., to Sir R. Fletcher.*

RIGHT OF Y^E GUADIANA,
May 10th, 1811.

SIR,

I have the honour to report to you that at 7 a.m. the enemy made a sortie from Fort Christoval and from the line between that place and the bridge—They gained the parapet of our battery, but were immediately repulsed—our loss I believe has been rather severe—Lt. Reid was in the battery at the time he has received a slight contusion, but he is not incapacitated from doing his duty—It gives me y^e greatest pleasure to report to you the very handsome manner in which Col. Hammond and all the officers of the Covering party speak of the gallantry and zeal of that Officer. The battery has received no damage from the enemy's Infantry, but has been much injured by the heavy guns from the place—

I feel it my duty to call your attention to the present state of our operations—with our present means we cannot employ more than 300 men and as I shewed to you yesterday a battery directed against the bridge and the bridgehead appears to be absolutely indispensible—

The enemy seem now to have directed their whole attention to the attack of y^e right of the Guadiana, and if you do not carry on at present operations against y^e place on the left of the river would it not be adviseable to increase our means on this side of the water that we may proceed with vigour and effect—If Capt. Hawkin's brigade of Arty., a brigade of British Infy., and entrenching tools for 600 men were sent to the right of the Guadiana we might carry forward our operations with more confidence and a greater probability of success.

I have the honour to be,
Sir,
Your very obedient servt.,
(Sd.) J. SQUIRE.

Half a battn. of riflemen from Gen. Alten's brigade would also be of y^e greatest advantage. If we receive these reinforcements an additional brigade of Engrs. would be necessary.

Capt. Dickinson joined me last evening.

J.S.

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(9). *Two letters from Sir R. Fletcher to Capt. Squire dated the 11th of May, 1811.*

CAMP BEFORE BADAJOS,
11th May, 1811.

MY DEAR SIR,

Finding our entrenching tools even more defective than I had believed, and those from England being actually at Elvas, we do not begin our further operations till to-morrow evening—I find from the Marshal that you are overpowered by fire, and I really think you would do well to block up your Embrazures entirely for the present, and even to have the guns withdrawn, that they may not be ruined by shells—I have ordered you English entrenching tools for 400 men immediately—I trust you will get them to-morrow morning, and 15,000 sandbags—

Ever very truly yours,
(Sd.) RD. FLETCHER.

CAPT. SQUIRE, Royal Engineers.

CAMP BEFORE BADAJOS,
11th May, 1811.

MY DEAR SIR,

I am truly sorry to hear that you have lost Capt. Dickinson and Lt. Melville—Pray have an inventory of their effects made, and the things themselves sent to Elvas, when you can.

We break ground this evening, and if your Battery can remain open in the morning, can you direct two or three of the guns to take in reverse and enfilade the guns in the Castle that can bear upon us—This might greatly assist us—If you cannot remain open, had you not better block up the Embrazures entirely, until your other Battery is ready ? From the number of shells I see thrown I hope you are well traversed.

Believe me,
Yours most truly,
RD. FLETCHER.

(10). **Two letters from Sir R. Fletcher to Capt. Squire dated the 14th of May*, 1811.

CAMP,
14th May, 1811.

MY DEAR SIR,

I have this moment received a letter from the Marshal saying that continuing the entrenchments on this side is now out of the question, and that it is useless to work on one side or the other—that he was only waiting (at 3 p.m.) for D'Urban to determine if to withdraw the

* These two letters evidently refer to the first raising of the siege which preceded the Battle of Albuera, fought two days later.—ED., *R.E.J.*

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troops to-night—As soon as the Guns and Stores are over I am to withdraw the Bridge at the mouth of the Caya—The Marshal says Soult was yesterday at *———— You had better send off to Elvas all you have. Your Batteries are now of little importance.

Yours ever truly,
RD. FLETCHER.

———

CAMP BEFORE BADAJOS,
14*th May*, 1811.

MY DEAR SIR,

If you have not already sent off all your stores, pray suspend that operation till you receive further directions, and do not destroy any timber, etc., that you did not think worth sending to Elvas—

Will you have the goodness to come over to me as soon as you can after the receipt of this letter. My Quarters are at an old chapel about 2,000 yards on the East of Badajos, and a little north of the Idowna Road—

Yours ever truly,
(Sd.) RD. FLETCHER.

CAPT. SQUIRE, Royal Engrs.

(11). *Report on Operations on the Right Bank of the Guadiana by Capt. Squire, R.E.*

CAMP BEFORE ST. CHRISTOVAL,
June 12*th*, 1811.

The attack on the right bank of the Guadiana consisted of four batteries with a parallel and trenches of communication. The batteries were numbered from the left and the Brigades of Engineers were distributed in the following manner :—

		24-Prs.				8-in. Howit.
No. 1	2nd Brigade	7	...	...	...	0
„ 2		3	...	...	...	2

The object of No. 1 was to destroy the batteries and dismount the guns in the Castle and afterwards to enfilade the front of the Castle attacked.

The object of No. 2 was to breach Fort Christoval with the Guns and to enfilade the line of the Castle with the Howitzers. Should the Scarp wall of Christoval be sufficiently destroyed by the guns of No. 3—No. 2 would co-operate with No. 1 in enfilading the front of the Castle attacked.

					24-Prs.
No. 3—7th Brigade	...	...	...	...	4

The object of No. 3 was to ruin the parapets and dismount the Guns in Fort Christoval.

		16-Prs.		10-in. Mortars.
No. 4—5th Brigade	...	4	...	2

* Name illegible.—ED., *R.E.J.*

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The object of No. 4 was to enfilade the Bridge and check sorties with the guns and with the two mortars to fire into Christoval and into the *tête-de-pont* if necessary.

The Parallel extended from No. 2 to the right of No. 4 and was about 900 yards in length.

The trenches were opened on the night of the 30th and 31st May.

Journal.

30th and 31st May.

Working Parties.

No. 1 and 2	400 men
No. 3	200 „
No. 4	200 „
Parallel	400 „
Total	1,200 „

Enough tracing fascines had been made at the Park to trace the whole line of the parallel.

The distribution of the Covering party delayed the commencing of our work; we did not break ground till 10 p.m. and the parties were withdrawn at daylight—½ past 3 a.m. Little progress made in Nos. 1, 2, and 3 on account of the rocky soil. No. 4 well advanced. The parallel opened and in the low ground cover obtained. On right of No. 2 soil rocky and not possible to remove without blasting.

31st May.

No. 1 and 2	100 men
No. 3	100 „
No. 4	100 „
Total	300 „

The platforms in No. 4 completed before sunset as well as three platforms in No. 3—obliged to blast the rock in No. 3 to make a level place for one of ye platforms.

31st May and 1st June.

No. 1	200 men
No. 2	200 „
No. 3	200 „
No. 4	200 „
Parallel	400 „
Total	1,200 „

The men at work generally at ½ past 8 p.m. and the same party continues at daylight the work at No. 1 and 2. Much interrupted by shot and shells, extremely well directed.

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The Guns and Mortars in No. 4 were mounted at midnight and 2 magazines finished.

June 1st.

No. 1	100 men
No. 2	100 „
No. 3	100 „
No. 4	100 „
Parallel	100 „
Total	500 „

The soil of No. 1—hard rock, obliged to blast for the platforms. The platforms in No. 2 laid this day—and 4th platform in No. 3—

June 1st and 2nd.

No. 1	200 men
No. 2	200 „
No. 3	200 „
No. 4	200 „
Parallel	200 „

The Parallel opened and generally completed to 8 feet in width. No. 1 and 2 much tormented by large shells well directed: the trenches to the right and left of No. 4 completed.

June 2nd.

No. 1 and 2	200 men
No. 3	100 „
No. 4	100 „

The men employed in filling sandbags at No. 1 and 2—at No. 3 and 4 in making trenches of communication and traverses.

June 2nd and 3rd.

No. 1	200 men
No. 2	200 „
No. 3	150 „
No. 4	150 „
Parallel	250 „

The platforms in No. 1 and 2 were laid yesterday: great difficulty in finishing the parapet of No. 1, it is made of sandbags filled in the rear with wool packs brought from Elvas.

June 3rd.

All the batteries ready to open at 7 a.m. The fire on this side of the Guadiana commences at ¼ before 10 a.m.

100 men employed in each of the batteries in making communications, traverses, etc.—

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Before sunset one gun—one mortar and one Howitzer disabled by our own fire. A 10-inch shell fell and burst on the angle of the large magazine in No. 2, but without doing any injury.

3rd and 4th June.

No. 1	...	...	...	100 men
No. 2	...	...	...	100 ,,
No. 3	...	...	...	100 ,,
No. 4	...	...	...	100 ,,

The embrazures and traverses repaired during the night, and a good parapet for musquetry formed on right and left of No. 4 and on right of No. 2.

4th June.

50 men employed at each battery in repairs, etc.: before sunset both mortar beds useless and one gun in No. 1, by our own fire—

4th and 5th June.

50 men at each battery for repairs, etc. Lt. Forster approaches the Salient angle of the ditch of Fort Christoval, and reports the ditch to be no obstacle. This night we commenced two additional Embrasures on left of No. 1—

June 5th.

50 men at each battery—Lord Wellington desires one gun to be added to the right of No. 1—and another to the left of No. 2—one gun disabled this day in No. 1 by its own fire.

5th and 6th June.

250 men.

200 employed on No. 1 and 2, in adding 3 embrasures for one Gun and 2 Howitzers in No. 1, and for 1 gun on left of No. 2: all but one embrasure for the Howitzer was completed during the night, and the 3 Platforms finished; the 2 Howitzers are mounted; No. 3 is dismantled and the guns moved forward to No. 1.

6th June.

50 men at each of the batteries. The enemy fire little from the Castle—

6th and 7th June.

150 men employed on repairs.

The breach in Fort St. Christoval though certainly not good appearing practicable for at least 2 men at once, it was decided to assault the place; particularly as Col. Fletcher had written to Lord Wellington stating that the main attack was extremely annoyed by a light gun from Christoval. The duty of accompanying the assaulting party fell upon Lt. Forster as first Subaltern, although he indeed most handsomely volunteered his services. The assault took place at midnight, and the troops retired at one a.m. having failed in their object. Lt. Forster accompanied the advance; on his arrival

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at the breach he found that the rubbish had been cleared away, and that all access was impossible: ladders were applied to the wall but in vain, the enemy making a most obstinate resistance, they filled the ditch with shells, grenades, stones and rubbish. Forster received a slight contusion at the breach. As he retired a musquet ball passed through his body, and his wound was considered mortal. His excessive bravery on this occasion was the admiration of all who saw him. Our loss in the assault was 102 killed and wounded.

7th June.

100 men employed in repairs, etc. In No. 1 and 2; only 7 Guns and 2 Howitzers serviceable, the rest disabled. Lord Wellington recommends a second attempt as soon as the breach of S. Christoval is improved.

7th and 8th June.

Working party—120 men employed in repairs, etc. Grape fired occasionally from the guns and howitzers to clear the trench, and prevent the enemy working.

8th June.

100 men employed at the batteries. At 8 meet Lord Wellington and Col. Fletcher when it was decided to assault Christoval this night, but Col. Fletcher having stated that to take Christoval was not now of so much importance as he had altered the approach that was enfiladed. I recommended that the assault should be delayed for 24 hours when the breach would be more practicable. My proposal was agreed to. Poor Forster breathed his last at ½ past 11 a.m.; in him we lose a most promising officer, his zeal and undaunted courage will for ever be remembered.

8th and 9th June.

100 men employed at the batteries—Grape and round shot fired upon the breach.

9th June.

100 men employed at the batteries. The assault of Christoval was decided upon for this evening and as Lt. Emmett was not well—the duty of accompanying the storming party fell upon Lieut. Hunt—

9th and 10th June.

100 men at the batteries—The assaulting party advanced at 9 p.m.—The resistance was most obstinate—At 10 our troops were compelled to retire—Such was the conduct of our Officers and men that if success had been possible we should have succeeded—Lt. Hunt of the Royal Engineers was killed at the crest of the glacis—he is spoken of by all who knew him in the highest terms.

10th June.

At 7 a.m. Lord Wellington having decided to raise the siege we began to move our stores and entrenching tools to Elvas—100 men at the batteries.

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10th and 11th June.

300 men—at the batteries.

Continue to empty sandbags and remove stores and timber during the night.

11th June.

Continue to remove stores and timber—200 men employed—

11th and 12th June.

200 men employed—

All the platforms, magazines, timber, etc., removed—and the batteries cleared before daylight—and the whole ready to be forwarded to Elvas—

(Sd.) JOHN SQUIRE,
Capt., Roy. Engrs.

(12). *Report on Execution of Assault.*

Execution.

June 9th and 10th, 1811.

Every arrangement being made and clearly understood by every officer and almost every man of the party—

Precisely at 9 the signal was made for the advance, and as the moon did not rise till ½ past 9, the different detachments arrived at the crest of the glacis without being perceived. As soon however as they descended into the ditch the enemy rolled down 5½-in. shells, grenades and fired musquetry from the parapets both at the Salient angle and the breach: the ladders however were planted in both places, but the enemy by means of large stones, and by poles threw down our men as they mounted to the assault. The gun in the flank of the left demi-bastion also fired upon the Salient angle. About ½ past 9 an Officer of y^e^ 51st arrived at No. 2 Battery stating that our loss was very great, that most of our Officers had been killed and that success was impossible. Capt. Maitland, Genl. Houstoun's A.D.C., immediately rode and informed the General of the fact; at ¾ past 9 he reached the battery and an order was dispatched for the retreat of the detachments. At 10 p.m. the whole had retired and all firing ceased. The Castle battery fired grape shot; we had also several shells from the town and the *tête-de-pont*. The enemy it seems had cleared away the rubbish at the foot of the breach—so that to apply ladders became necessary, but with such resistance success was impossible. Every exertion was made both by Officers and men that could be made by the bravest troops in the world.

Christoval can only be taken by advancing our batteries to the crest of the glacis.

(Sd.) J. SQUIRE,
Capt., R.E.

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ECHOES FROM THE ENGINE ROOM.

(*Continued*).

By "INSPECTOR."

ECHO NO. 14.

HEAD AND LIFT.

When a pump is installed to shift water from one (lower) level to another (higher) level the difference in height between the two levels may be referred to as the "total static head," or briefly as the "static head." Ordinarily the pump will be sited somewhat above the lower level and appreciably below the higher level, under these conditions water will have to be lifted on the suction side of the pump and pushed on the delivery side. Apart from the "head" due to the actual difference of levels the flow of water will be opposed by the friction in the pipes and valves, in the pump, and in the meter, if any. Hence the "total head" to be pumped against will consist of the static head plus friction head, and as regards the latter it must not be forgotten that it occurs upon the suction side of the pump as well as upon the delivery side. Broadly speaking the friction varies in a complicated way, but with any given size of pipes and apparatus the resistance due to this cause varies directly as the square of the number of gallons passing, whether those gallons be lifted, pushed, or flow by gravity.

Although convenient to refer to the total head upon the suction side of the pump as the "lift," no intelligent reader will suppose that the water is actually lifted. The pump creates a vacuum, more or less imperfect, whereby the weight of the atmosphere acting upon the surface of the water in the (presupposed) well is enabled to push the water up the suction pipe to a height dependent upon (i.) principally the degree of vacuum produced and (ii.) the frictional resistance offered to the flow of the water.

The maximum "lift" against which a pump will work depends somewhat upon the type and design of pump. A pump-end with large clearance spaces and with badly arranged valves will have a smaller maximum lift than, say, a well-designed piston pump with small clearances. The differences in this respect are however eliminated almost entirely if adequate arrangements are made for charging the suction pipe with water or for exhausting the air from it before the pump is put to work. These points are dealt with at greater length under the heading of "Suction Chamber" and in what follows here it is assumed that although the pump is not unduly handicapped by design or otherwise, no special air exhausting device is provided.

Were the pump capable of producing a perfect vacuum it would be permissible to make the lift nearly equal to the number of feet head of water equivalent to the absolute air pressure at the locality. The vacuum theoretically attainable depends upon the height of the

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place above sea level and upon the temperature of the water to be pumped. For practical purposes it is near enough to take the vacuum attainable at sea level as equivalent to 33′ "lift" with water not exceeding 60° Fah. For heights above sea level it is near enough to allow a deduction of one foot of "lift" per 1,000′ increase in elevation. An engineering pocket-book may be consulted as to the necessary correction for temperature of water. In practice this correction may be ignored as regards pumping stations unless the temperature of the water exceeds 60° Fah., but it can by no means be neglected if the water to be pumped in is what is commonly called "hot," *e.g.*, the condensed steam discharge from air pump of condensing plant, or water after treatment in a feed water heater. It is commonly stated that when the water is "hot" it must gravitate to the pumps, and although this can generally be arranged for there seems to be no just cause why such water should not be "lifted" if necessary, subject to a suitable limitation upon the lift attempted. In the case of a pumping station it is undoubtedly desirable that the water should gravitate to the pump upon the suction side, but actually it is generally necessary to lift the water more or less upon that side.

It frequently happens that the water in a well falls while pumping is in progress, so that there may be two water levels to be considered, viz. :—(i.) the normal level, (ii.) the working level.

The "actual" lift against the pump reckoned from normal level should not exceed 70 per cent. of the lift theoretically attainable, and the corresponding figure for the working level should not exceed 75 per cent. with an outside limit of 80 per cent. of the lift theoretically attainable from that level. For example, if the friction is calculated as 2′ ; then, at sea level, the suction valves in the pump barrel should be not more than $\frac{7\times(33-2)}{10}=21{\cdot}7'$, above the normal water level (cold water). And under those conditions it would be unwise to rely upon the pump, while working to lower the water level more than $\frac{75\times(33-2)}{100}-21{\cdot}7=1\frac{1}{2}'$, and the pumps would almost assuredly cease to draw water at all when the *total* lift amounted to $\frac{8\times33}{10}=26{\cdot}4'$. Although when everything is in first-class order it may be possible to somewhat exceed the limits given above, *e.g.*, if a suction vessel with steam ejector is fitted on the suction pipe, under no circumstances whatever should the 80 per cent. limit be exceeded.

The above figures refer to pump ends of 6″ diameter and upwards and to centrifugal pumps of 6″ size and upwards; smaller pumps cannot be relied upon to work up to those limits. As much as 7′ should be deducted from the figures for reciprocating pump ends of 3″ diameter, and for centrifugal pumps the corresponding deductions would be about 5′ for 4″ size, and 10′ for smaller sizes.

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Echo No. 15.

AIR VESSELS.

It is usual to provide all reciprocating pumps, except the smallest sizes, with an air vessel on the delivery side; failing this an air vessel is sometimes fitted on the delivery main itself, close to the pump outlet.

The object of such an air vessel is to reduce the fluctuations in the flow of water caused by the successive strokes of the pump and thereby eliminate water hammer in the rising main. It also acts as an elastic cushion and enables the pump valves to open and seat themselves with less shock.

A pump with which the variation in rates of flow is great should apparently have a bigger air vessel than would suit a pump for the same output but with a more even delivery. For example a single acting single ram pump should have a larger air vessel than a double acting duplex Worthington pump. That there is nevertheless some doubt in the matter appears evident from the practice of different makers. The variation in flow from a triplex power pump with single acting rams is small provided all three rams are working properly, nevertheless most modern pumps of this type have an air vessel and in some cases there is a separate air vessel for each ram. Again some of the earlier double acting duplex Worthington pumping engines had very large air vessels, but modern examples of these pumps have air vessels that are exceedingly small for the size of pump, the contention being that the variation of flow is so small a large vessel is unnecessary. Yet with another make of pump also double acting and duplex, but of the flywheel type, quite a large air vessel is provided. A final instance may be mentioned of a double, differential-ram flywheel pumping engine of about 25-H.P. working well and quietly at a ram speed of 127′ per minute, against a head of 1,500′ without any air vessels at all.

It is probably open to question whether the small air vessels on modern Worthington pumps are really big enough, and it is thought that the differential ram pump referred to could be run faster without knock were it equipped with air vessels. In support of this view it may be mentioned that an air charging apparatus for insuring that the air vessels may be kept filled or partly filled with air, forms an integral part of the Oddie-Barclay express pumps and of the larger sizes of hydraulic rams, and such apparatus is sometimes provided with large pumping machinery. In the case of a small Worthington pump not fitted with an air vessel it was found possible to increase its speed and output some 10 per cent. after an air vessel had been fitted. In one case a 15-H.P. modern Worthington pumping engine running at 55 cycles per minute (ram speed is 92′ per minute) delivers through a steel main into a steel reservoir against a head of 850′. Standing by the reservoir it sounds as if some one was hitting it hard with a good big hammer. The pipe in this case has flanged joints which have withstood this hammering satisfactorily for years, but it is

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suggested that the hammering would be much lessened or, indeed, eliminated were the air vessel on the pump larger.

The examples referred to indicate the uncertainty that exists as to the size of air vessel to be provided or indeed as to whether any such adjunct is necessary at all. It is however contended that not only should an air vessel be used but that it should be properly located and of a size suitable to the size and type of pump.

For a single acting, single ram, pump the volume of the air vessel may be equal to as much as 20 times the displacement of the ram per stroke. For single, or double, acting 3-throw pumps the air vessel has, in some designs, been given a volume as large as ten times the displacement of one stroke of one ram; this is perhaps needlessly large. For two barrel double acting pumps (more or less corresponding to an ordinary "duplex" pump) an air vessel equal in volume to 12 times the volume of one pump barrel is not unusual. No definite rules can be given, but a volume equal to six times the displacement of one stroke of one side or section of the pump seems an approximate *minimum* figure. With pumps of about 15-P.H.P. and upwards it would usually be worth while fitting the air vessel with gauge glass and cocks.

To be effective an air vessel must be suitably placed relative to the flow of water which it is intended to control. The more directly the water can flow straight into the air vessel the better chance has that vessel of satisfactorily performing its proper functions. If the pump is sited on a hillside or if the pump is placed below the general ground level in order to get within suction distance of the water it is probable that the delivery pipe rises, more or less, straight away from the pump. On the other hand the delivery pipe will, in many cases dip down after first leaving the pump. In the former case it may be best to purposely introduce some change of direction in the rising main, at, or close to, the pump, in order to locate the air vessel effectively, unless the vessel can be placed on the pump itself. In the latter case the air vessel should be placed on the pump side of the dip referred to. In two cases known to "Inspector" an air vessel has been fixed on the side of the dip remote from the pump, and although the air vessel in each case is large it seems to make but little difference whether it is full of air or has no air in it.

In conclusion it may be remarked that the matter is by no means a simple one, for, whereas in one case it may be found advantageous to work with the air vessel nearly full of water, in another it is preferable to use a large air cushion.

ECHO NO. 16.

VACUUM VESSEL.

An air vessel fixed on the suction side of a pump may be conveniently called a vacuum vessel although if the water gravitates to the pump the mean pressure in such a vessel will be more or less above atmospheric pressure.

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Unless the suction pipe is quite short, a vacuum vessel on the suction side of a pump is no less desirable than is an air vessel on the delivery side, whether the water gravitates to the pump or has to be lifted. In the former case the pressure on the suction side may, due to the inertia effect of the water, reach an incredibly high figure if no vacuum vessel is provided, and in the latter case the presence of the vacuum vessel equalizes the flow of water in the suction pipe and gives the pump a better chance of drawing a full stroke of water.

It is relatively unimportant if there is a change of direction between the suction pipe and the pump but the vacuum vessel should be fixed so that the water can flow directly into it, and it should, preferably, be placed close to the pump.

As regards size, a vacuum vessel, which acts merely as a shock absorber in the manner indicated above, may be made not smaller than half the size of the corresponding air vessel. If, however, the vacuum vessel also acts as a "suction chamber" it will be desirable to make it at least equal in size to the air vessel.

ECHO NO. 17.

SUCTION CHAMBER.

If the water has to be lifted from below the level of the pump, the simplest possible arrangement is when the pump is fixed directly over or quite closely adjoining the well or sump from which the water is to be drawn. In such a case the pump when put to work will draw its water without any special arrangements for charging the suction pipe unless the "lift" approaches the permissible maximum. In any case however it is desirable to provide a by-pass from the rising main to the suction pipe, and if the "lift" is large such an arrangement, or some equivalent device, is necessary.

To insure smooth working it is desirable that the pump should draw a full charge of water every stroke, it is a particularly painful and thrilling spectacle when a "Straight Line" pump misses its water. Now "ordinary" water contains a certain amount of air in suspension and if the lift is great this air is liberated under the influence of the partial vacuum formed and is liable to cause a missed or partially missed stroke unless arrangements are made to get rid of it.

If the water supply is drawn simultaneously from several wells in the neighbourhood of the pump it is convenient to connect the several suction pipes to a cylindrical "suction chamber" fixed close to, and on the same level as, the pump or pumps. In this case the suction side of the pump is connected by quite a short pipe to the suction chamber and no separate vacuum vessel on the pump is necessary.

A suction chamber forms a convenient means of coupling up the various suction pipes, and its diameter may be more or less governed by the number of connections to be made at it. Except in so far as it serves as a junction point and as a vacuum vessel for the pump the

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suction chamber need not be considered in any other *rôle* if the "lift" is small, and indeed its place might be economically filled by a combination of a vertical piece of piping with "Y" and other junction pieces.

Again, if the lift is small a by-pass arrangement as already referred to will suffice for charging the suction pipes with water. Although the suction pipes are fitted with foot valves it is as well not to make the by-pass, or charging, pipe too small as the foot valves may not be quite tight.

On the other hand if the lift is large the "suction chamber" has an additional important function to perform in that it acts as a collecting point for the air that escapes from the water. Under such circumstances the suction chamber should be equipped with gauge glass and fittings and with some device for exhausting the air from it and from the suction pipes both before the pump starts and also while the pump is at work. If the plant is steam driven the most convenient device for this purpose is a steam ejector (similar to the apparatus used in conjunction with the vacuum brakes on railways). For electrically operated plant or oil engine installations it seems to "Inspector" that some form of vacuum pump should be provided, although with crank controlled or flywheel pumps the necessity for a full water stroke every time is less imperative. With a suction vessel fitted in this way it is possible to keep the level of the water in the vessel above the outlets to the pumps and thereby insure a full charge of water for every stroke. The arrangement works admirably in practice, but in order to enable it to satisfactorily meet this additional function and at the same time avoid having to frequently operate the ejector the suction vessel should be made fairly large *i.e.* its height may be equal to from three to four times its diameter. Examples from actual practice are of the following sizes:—(*a*) 10′ 6″ × 4′ diam.; (*b*) 10′ × 2′ 6″ diam.; (*c*) 6′ × 1′ 9″ diam.

It may be noted that the suction pipes from the wells should enter the suction chamber close to the bottom, either all on one level or, in order to avoid making the diameter of the chamber needlessly large, the inlets may be arranged on two planes. The outlets to pumps may be on the same level as, or below, the inlets. The inlets and outlets should be individually controlled by full way sluice valves at the suction chamber. The ejector should be fixed on or close to the suction chamber and its suction be connected, through a valve, to the top of the chamber. A properly designed ejector may be reckoned upon to give a vacuum within 6″ of the barometric column when supplied with steam at a suitable pressure (between 80 to 140 lb. per square inch). Special air ejectors are also made which will give a vacuum within 4″ of the mercury column if the steam pressure applied (between 50 and 100 lb. per square inch) is properly adjusted to the requirements of the case.

(*To be continued*).

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THE VARIOUS SYSTEMS OF MULTIPLEX TELEGRAPHY.

By MAJOR W. A. J. O'MEARA, C.M.G., LATE R.E.

(1). INTRODUCTION.

THIS paper deals with the various systems of telegraphy which, when working on a single line, enable one to utilize the available channels of communication either wholly in one direction or partly in one and partly in the other direction. Systems which provide more than one channel either by means of the duplex balance only or by loop circuit working with one or more channels superposed, are intentionally excluded.

Multiple systems naturally divide into certain distinct classes according to the way in which the currents are utilized for transmission. These are indicated by the following divisions :—

Class I. Signalling currents which vary not only in strength, but also in direction.

Class II. Signalling currents of moderately high frequency working in conjunction with others of different frequencies, or with ordinary telegraph currents.

Class III. Signalling currents built up of a series of impulses sent at short and very frequent intervals.

Class IV. Signalling currents consisting of a number of impulses of varying duration sent at regularly recurring intervals.

In the limited time at my disposal, it is not possible to deal with every system, and I do not therefore propose to do more than briefly refer to the principles involved, as full details of every system can be found in technical literature. The advantages and disadvantages of each of the systems mentioned are however briefly stated in this paper.

(2). MORSE QUADRUPLEX.

Class I. is well represented by what is known generally as the Morse Quadruplex with its many variations. To adopt Multiple terms, it is what one would designate a Morse Double Duplex.

Although the main features of the system have not changed since it was first introduced into the telegraph service of Great Britain, much has done in recent years to increase the flexibility of the

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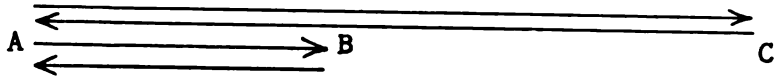
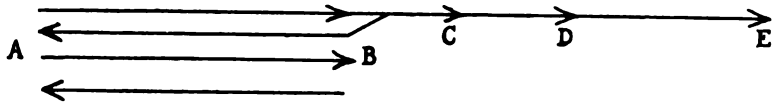
system in order that the channels available may be utilized to the greatest advantage.

The later-day developments of the quadruplex system are shown diagrammatically in the following cases where the lines indicate the working channels with the arrow-head indicating the direction of working.

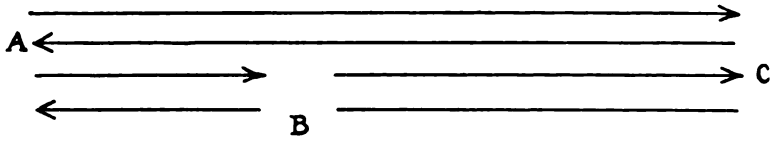
(1). Quadruplex with two channels extended.



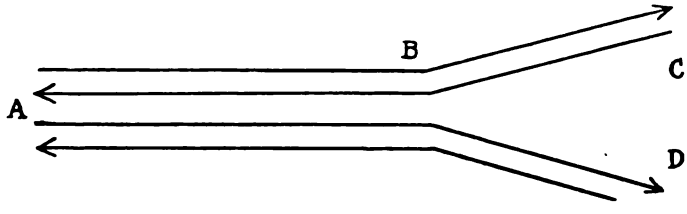
(2). Quadruplex with two channels extended as one channel to an omnibus circuit.



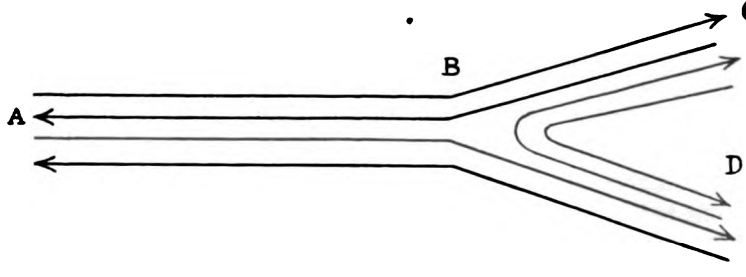
(3). Quadruplex with two channels extended to two others of a second quadruplex.



(4). Quadruplex with two channels extended to each of two different stations.



(5). Quadruplex with two channels extended to each of two other stations on a wire by which they are working quadruplex.



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In the British Isles there are many of these extended circuits. In two instances a Quadruplex Repeater is used where an 80-mile section of submarine cable is joined to about 120 miles of aerial line. The repeater is distinctly complex, but it works well as specially qualified officials are in constant attendance. Although usually the four channels of quadruplex sets are worked by hand at a speed of about 25 words per minute, the polarized relay channel is often fitted with a Wheatstone automatic system working up to a speed of 150 words per minute or less according to the difficulty of the line. The amount of traffic that can be disposed of is therefore a very variable figure, and differs so greatly in different circumstances that actual figures obtained will be of no practical use without a considerable amount of detailed explanation. For this reason the speed rate of each channel in words per minute is perhaps the most useful guide for all practical purposes. It is obvious that on the polarised side, highly expert operators could work up to 40 words per minute or more: whereas on the non-polarized side where the signals are mutilated, it would not be advisable to exceed a speed of about 25 words per minute. The system has been found well suited for small offices, as its maintenance requires no mechanical skill and very little electrical knowledge beyond a few general rules for adjusting the different parts of the apparatus.

Its cost is also very low as compared with some other multiple systems, one complete terminal set costing about £35.

It may be of interest to state that at one time there was a strong division of opinion on the relative merits and advantages of the Decremental (see Appendix) as opposed to the Incremental system of working the "B" side of the quadruplex. The two systems were therefore given a prolonged trial under practical working conditions lasting a number of years. There is now no doubt that for practical purposes the Incremental method has some slight advantages and is now universally employed in Great Britain.

For many years a relaying sounder was employed in local circuit between the non-polarized relay and the reading sounder to overcome the breaks in the signals. As this arrangement involved the correct adjustment of two instruments, trouble was often experienced. Some six or seven years ago, the relaying sounders were replaced by condensers and resistance coils (see Appendix) resulting not only in economy in first cost of the plant obtained, but in a considerable simplification of the adjustments, thus rendering the system a more stable one. These changes have in consequence reduced the annual maintenance charges.

The system unfortunately still has its weaknesses, chiefly due to the fact that one cannot reverse the direction of current in a line without momentarily having no current on that line; that is to say, in reversing the current, the signalling key must either momentarily

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short-circuit the battery or disconnect it. This momentary interruption mutilates the signals which actuate the non-polarized relay, necessitating the use of special devices at the receiving end to mask the distortion. Unfortunately the extent of the distortion increases with the length or difficulty of the line, thus seriously limiting the practical application of the system. There are however very many lines of moderate length ranging up to 400 miles for a copper aerial line or 120 miles for an underground cable line where this system works quite satisfactorily.

(3). MERCADIER.

Class II. is well represented by the Mercadier system in which different rates of alternating currents are supplied at the transmitting end to actuate receivers which respond only to one particular frequency at the corresponding terminal station. The actual reception, if by Morse code, is obtained by the transmission of groups of long and short series of current alternations. If for Hughes working, then by the transmission of equal series of current alternations at varying intervals. The Morse or Hughes receiving instruments are in local circuit with the tuned receivers.

This system, although not adopted on British telegraph lines, has been subject to experimental investigation on two or three occasions. The results obtained have certainly demonstrated the practicability of the system from the point of view of the inventors, but the system unfortunately possesses the objectionable feature that serious disturbances are produced on neighbouring telephone circuits—described by some telephone users as resembling the singing of a number of birds.

The frequency used ranges from 480 alternations per second to 900. This obviously requires a line having a high transmission efficiency—equal to a Wheatstone speed of about 2,000 words per minute.

Owing to the close intermixing of telegraph and telephone lines in Great Britain, the system could not be generally adopted, although in certain cases where line conditions were favourable, it would prove very useful.

(4). PHONOPORE.

On a smaller scale the Phonopore is somewhat similar in principle to the system last described. It provides one channel for the ordinary Morse signals, and a second channel on which the Morse code is signalled by means of rapidly alternating currents cut up into short and long groups of current impulses.

The phonopore has been adopted to some extent by railway companies in England.

This system has also the drawback that it interferes with the satisfactory working of neighbouring telephone circuits although

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the disturbing effects produced are not so serious as those caused by the Mercadier. The disturbances created, however, are of a sufficient magnitude to prevent the system being adopted by the British Telegraph Administration owing to the difficulty in providing separate routes for telephone and telegraph circuits.

(5). Picard.

The Picard is used in France to operate Hughes apparatus in the ordinary way on one channel, and to operate a second Hughes channel by rapidly alternating currents.

Neighbouring telephone circuits are disturbed by this system somewhat in the same manner as by the Phonopore, but the interference is much less than in the previous case owing to the fact that the Hughes instrument requires only one signal per letter, as compared with an average of four for the Morse.

The Hughes, however, is not used on short lines in Great Britain, and its use is confined to a few long underground cables on which it is worked duplex, or for International circuits which would not be suitable for carrying the second channel. For these reasons there is no field for this system in Great Britain.

(6). Delaney.

Class III. is well illustrated by the Delaney system in which the separate channels are worked by the usual Morse keys each sending continuously at a rate of about 25 words per minute. A distributor at each end automatically connects the line to the several corresponding sending and receiving sets for brief but frequent intervals. This obviously means that the signals are mutilated before going out to line and necessitates the use of devices at the receiving end to rectify the distortion. This distortion increases with the length of line and results in rather delicate adjustment of the distributor speeds and the receiving apparatus. The system worked well for a number of years on several circuits in England, but eventually had to be abandoned because of the more or less imperfect character of the signals, a defect which increased as it became necessary to gradually increase the length of the underground sections in the lines leading into the important centres of communication.

The reeds controlling the apparatus proved a considerable source of trouble, and required to be carefully supported on rubber rings to avoid being disturbed by extraneous vibrations of any kind, as the smallest variations in the speed of the distributors at once caused trouble.

The actual line speed required was very high being something in the neighbourhood of 600 words per minute for an output speed of from 75 to 150 words per minute. On short lines where there was

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ample margin of speed, the system was extremely useful as the channels numbering in some cases up to six could be used at any moment in either direction as required, by merely turning a switch at each end of the channel affected.

The apparatus was designed to meet the most difficult traffic requirements, and thus in practice it was possible to utilize the channels at any instant either wholly in one direction, or any number of the channels in one direction and the remainder in the other.

(7). POLLOCK-DELANEY.

In order to improve the general working of the Delaney system, Mr. S. A. Pollock, of the British Post Office Engineering Department, developed a duplex arrangement of a quadruple set which, in addition to providing eight channels, enabled longer segments to be used resulting in the reduction of the line speed required from about 600 to 220 words per minute for an output speed of from 100 to 120 words per minute in each direction. The set worked very well indeed, and 400 to 480 messages in the hour were actually handled on a single aerial wire 180 miles long.

This apparatus was eventually abandoned on account of the difficulty in maintaining a sufficiently accurate balance (for the speed required) on aerial lines in the variable climate of England, and because the other lines working between the two towns where this apparatus was fixed were not suitable for the high duplex speed necessary owing to long sections of gutta-percha-covered wire forming parts of the lines; consequently an interruption on this line caused considerable disorganization of traffic by so largely reducing the number of channels between the two centres.

(8). MEYER.

I now come to the fourth class in which the line is joined at regular periods to the different channels in succession, thus allowing the signals to go out to line without being mutilated, and in consequence securing the best possible condition for signals being received in the most perfect form.

This method originated in the Meyer Multiplex, where an 8-key transmitting device was utilized to form a Morse letter in connection with a distributor which sent out the signals to line, once per revolution. At the receiving end each Morse letter was printed across a tape instead of along it as is now the general practice. The sending was performed by forming one letter per revolution of the distributor on each transmitting device or keyboard. The correct time for the formation of the letter being indicated to the operator by a cadence signal. This arrangement did not present any serious

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disadvantages, but the received record had to be transcribed from the slip instead of being written up from a sounder as in the Delaney.

The invention of the Baudot which did away with the tedious operation of writing up from slip very soon displaced this system.

(9). BAUDOT.

The Baudot is another representative of the fourth class.

Owing to the method of sending complete signals successively on the different channels between the different sets of corresponding apparatus the line speed required is not high, and a further advantage is obtained by using a shorter code than the Morse.

The line speed required for any particular type of Baudot is shown in the following tables in which the calculations have been made on the recognised basis of 30 segments per word for Baudot and 48 unit impulses per word for Wheatstone.

Types of Baudot with Output Speed, etc.

Type.	Output Speed w.p.m.	Equivalent Morse Speed.	Output in Messages per hour of Average British Message of about 20 words.	
Double	60	49	100 to 200	50 to 60 per Channel.
Double Duplex ...	$\begin{matrix}60\\60\end{matrix}$ = 120	$\begin{matrix}45\\45\end{matrix}$ = 90	200 „ 240	
Triple	90	67·5	150 „ 180	
Triple Duplex ...	$\begin{matrix}90\\90\end{matrix}$ = 180	$\begin{matrix}64·7\\64·7\end{matrix}$ = 129	300 „ 360	
Quadruple ...	120	90	200 „ 240	
Quadruple Duplex	$\begin{matrix}120\\120\end{matrix}$ = 240	$\begin{matrix}82·5\\82·5\end{matrix}$ = 175	400 „ 480	
Sextuple	180	120	300 „ 360	
Sextuple Duplex...	$\begin{matrix}180\\180\end{matrix}$ = 360	$\begin{matrix}120\\120\end{matrix}$ = 240	600 „ 720	

The vast difference in line speed required for a Sextuple Baudot and Sextuple Delaney is most marked, the Baudot requiring only one-fifth of that required for the Delaney. Further, the Baudot gives typed characters at the received end as compared with more or less accurate Morse signals on the Delaney.

Another great advantage of the Baudot system is as in the Morse Quadruplex the practicability of obtaining separate channels on one

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wire working quite independently to different stations. The Baudot has been adopted in England comparatively recently for inland working, and sufficient apparatus is not yet available to carry out any comprehensive scheme involving the most advantageous use of line plant. The French Administration has courteously placed much information at my disposal, and it is therefore possible for me to give the following circuit arrangements which will, it is hoped, give some idea of the elasticity and value of the Baudot system.

The London-Paris-Zurich-Marseilles circuit consists of a single wire London to Paris, a single wire Paris to Zurich and another single wire Paris to Marseilles. On this circuit London works two channels to Marseilles, and two channels to Zurich while Paris also works two channels to Zurich. The circuit works exceedingly satisfactorily, and there have been fewer stoppages between London and Zurich since this arrangement was installed than when a simplex Hughes was being worked between London and Zurich.

The Paris-Algiers communication works over one wire Paris to Marseilles, and three submarine cables each about 800 kilometres long between Marseilles and Algiers. Four channels are worked between Paris and Algiers (three in one direction and one in the other, as required) while Marseilles works two channels with Algiers, one in each direction.

It is surprising that such a promising invention has taken so long a time in finding appreciation outside the country of the inventor. Although it is some 30 years old, it is only during the last few years that it has commenced to attract serious attention. Its use is now, however, spreading rapidly in Europe and Asia ; the Russian Administration it is understood, has already installed during the last five years about 75 sets and the Telegraph Administration in British India has installed 30 sets during the same period.

The British Telegraph Administration has to deal with a somewhat difficult requirement. Owing to the very cheap newspaper tariff rate, very special conditions have to be met in dealing with this class of work, and the Baudot so far has not been found suitable for the purpose.

The Wheatstone which was first in the field holds its own for this class of work, but the use of the Baudot is likely to be extended in the British Isles for handling ordinary messages.

Twelve quadruple sets have already been installed, and provision has been made for installing the equivalent of at least ten more sets during the next twelve months.

The Baudot has been developed in France as a simplex system only and this, it is understood, fully meets the telegraph requirements of that country.

An officer of my staff, Mr. A. C. Booth, has made a very careful study of this system and has successfully duplexed the Baudot.

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In October, 1910, the Engineering Department of the British Post Office installed a quadruple duplex giving eight channels (four in each direction) on an underground line between London and Birmingham, also a double duplex between London and Berlin over a submarine cable of about 500 kilometres in August, 1910. The results obtained on these circuits have been eminently satisfactory, so much so indeed that the German Administration have been encouraged to fit a double duplex on an underground line having two repeaters between Berlin and Cologne.

The British Telegraph Administration is about to take another step forward, for it is proposed shortly to instal a sextuple duplex between London and Birmingham. If this experiment should prove successful, and there is every reason to expect that it will, then the Baudot system will prove itself to be the most expeditious machine printing telegraph system yet invented for dealing with large volumes of traffic.

The Siemens Photographic Printer has proved, under experimental working conditions, to give the highest rate of transmission of all the printing telegraph systems investigated in England. It is not, however, a multiple system, and therefore the treatment of its features does not come within the scope of this paper.

(10). Murray Multiplex.

I come now to what may be termed an offspring of the Baudot, namely, the system devised by Mr. Donald Murray. Mr. Murray has adopted the Baudot code but has designed his printing mechanism on entirely different lines. Instead of printing on tape from a revolving type-wheel, a small typewriter is used, and the messages are printed in page form entirely automatically. Special signals are used at the transmitting end to control all the movements necessary to move the form for each fresh line, and also to put a fresh form in position.

The complete installation is a distinct advance on the Baudot system, as each channel works at the rate of 40 words per minute as compared with 30 words per minute on the original Baudot. A great saving in labour is expected from the adoption of page printing as the received message only requires to be checked as the forms are withdrawn from the typewriting machine. It remains to be seen whether on aerial lines subject to occasional interruptions any real advantage will accrue from the method of reception in page printed form, or whether actually this will prove to be a positive disadvantage. The experiments now being made in England are not sufficiently advanced for any conclusions to be drawn on this point. The experimental installation is a double duplex giving four channels working at a total speed of 160 words per minute (80 in each

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direction). Unfortunately, figures are not yet available as to the amount of traffic that can be dealt with in the hour. It is however believed that very good results will be obtained in the trial equipment, and Mr. Murray hopes to be in a position to work triple duplex, quadruple duplex, or sextuple duplex with his system.

(11). MUNIER.

The Hughes instrument has from time to time been arranged for multiple working with a view to increase the output speed of the line. One of the methods to effect this purpose is that known as the Munier arrangement whereby the output of the line was increased by about three times by equipping it with four complete sets of Hughes apparatus at each end of the line, a fifth set being used as a distributor. This arrangement does not allow the maximum speed of each Hughes set to be developed, since only one signal can be sent per revolution. The reduction is equivalent to about 30 per cent. of the mean speed. Naturally the letters composing words do not follow the sequence of letters as arranged on the type wheel for printing, and therefore the average output speed is about one-fourth of the actual printing speed. The simplicity of the transmission is in its favour, being theoretically four times more favourable than the Morse. These two features therefore are opposing factors, the result being that the Hughes output under average working conditions is about the same as Morse. That is to say, a Hughes working at 120 revolutions per minute, although its printing speed is 112 words per minute, gives an output speed of 28 words per minute and requires a line speed of 28 words per minute Wheatstone but it has a great advantage over the Wheatstone as regards the transmission of figures. This amounts to about 65 per cent. The natural delicacy of the apparatus itself, if added to the additional difficulties of any multiple system, render the whole a rather unreliable combination, and this is no doubt the reason why so very little has been done with the Hughes instrument as a multiple system.

(12). ROWLAND.

This system which provides four channels in each direction by means of the duplex balance, was given a somewhat extended trial in the United States of America, but is now no longer in practical use. It is capable of working at a speed of 40 words per minute on each channel, giving an output speed of 160 words per minute each way. The apparatus is rather elaborate, as the page printing method of reception is provided for and controlled entirely from the sending end on each channel.

The disadvantage of the system is the comparatively large number

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of signals per letter, 12·5 units as compared with eight for the Wheatstone and six for the Baudot.

The fairly high rate of working at 160 words per minute is equivalent to a speed on Wheatsone of 250 words per minute. For such a speed at duplex, the balance must be very accurate and is necessarily delicate ; also the disturbance produced on neighbouring conductors is fairly considerable. The electrical and mechanical parts are somewhat numerous and require some skilled attention to maintain in good working order.

The saving of labour by the use of page printing is an advantage in certain conditions ; but taken as a whole, the disadvantages of the system outweigh the advantages as compared with other systems that are available. The operators signal direct on to the line, and in consequence false signals are recorded on the forms at the receiving station. It is difficult to make corrections on the forms which have to be sent out to the public in a manner sufficiently satisfactory not to disturb the confidence of telegraph users. When the system was in use in America, the practice was adopted of rejecting the forms on which false signals appeared, and in consequence the messages had to be completely resignalled, and the system thus proved costly and unsatisfactory.

Conclusion.

In considering the question of the utility of the Multiplex systems, it is necessary to compare them with the automatic high speed systems because the problem of telegraphic transmission must be viewed from several standpoints, the more important of these being :—

(*a*). Saving in wire mileage.
(*b*). Saving in labour costs.
(*c*). Saving in maintenance costs.
(*d*). General convenience of system with special reference to the handling of messages and the correction of errors.

Multiplex systems are not only in competition with each other, but they are as a class in competition with the high-speed automatic systems.

The character of telegraphic traffic falls into two definite classes so far as Great Britain is concerned, one, consisting of comparatively short messages dealing either with commercial or domestic affairs, and the other consisting of newspaper messages which are often exceedingly lengthy. The former embraces the greater bulk of the work which has to be handled and requires to be dealt with very expeditiously as small units. The latter also requires expeditious treatment, but can stand the initial delay of the few minutes required for preparing the perforated tape, so long as its reception at the newspaper office is in

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time for printing. With the increase in the number of newspaper editions that are now published, the latitude in this direction has been considerably diminished.

It will be readily understood that the question of rapid transmission of messages and delivery at their destination becomes a highly important factor in the situation, owing to the short distances between large centres and the highly developed railway facilities now provided between such centres.

It seems to me from a general view of the situation that it is preferable for the short messages to be handled as complete units rather than that a number of such small messages should be put together in bulk at the transmitting end and signalled as one continuous stream of signals which have to be again cut up, and checked. If repetitions or verifications are necessary considerable delay to the units concerned arise owing to the references required and the search that has to be made to trace them and signal them forward. With a multiplex the message is dealt with immediately it is received and corrections, etc., are asked for and given at once without any delay. Further, the Multiple systems have the great merit of enabling the fullest use to be made of the line time in dealing with not only long but with short messages also. The general public have in consequence the advantage of a quicker service than is possible with ordinary high speed transmission systems requiring the preliminary preparation of a perforated tape.

Opinions are still divided on the subject of reception by tape as compared with reception in page form. If the matter is considered from the point of view of a quick and cheap service which avoids all the waste of time involved by using elaborate means for disguising errors or corrections and in other ways to improve appearances, in the form and not the substance of the message, then the tape form of reception is superior to the page form.

It seems probable that future developments in printing telegraphs must follow the lead of the Baudot principle on account of the great advantage in respect of the saving of line time, and from the point of view of simplicity in mechanical details.

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APPENDIX.

(1).

The Decrement Method of Morse Quadruplex.

By C. C. Vyle.

In the Decremental quadruplex the tongue of the non-polarized relay is normally held by a spiral spring against the spacing contact and when the current is decreased sufficiently, the tongue moves over to the other contact known as the "marking" contact, to actuate the sounder.

The Decremental system does not avoid the difficulty that arises when the current in the line is reversed, but the arrangement changes the effect from a tendency to split the signals which exists in the Incremental system, to a tendency to prolong the signals excessively in the Decremental system.

The advantages claimed for the Decremental system are:—

(1). Simplification of adjustment as it is easier to correct prolonged signals than to avoid split signals.
(2). Slightly less apparatus required.

All facilities such as extensions and repeating arrangements offered by the Incremental system are also provided in the Decremental arrangement.

As the description of the Decremental method does not appear to have been published, a diagram of the connections is shown on page 366.

(2).

Quadruplex (Increment System).

Local Circuit of "B" Side.

By C. E. Hay.

It is very necessary to obtain the most suitable values of resistances and capacity to bridge over the unavoidable mutilation of the signals that actuate the B relay and these values for the local circuit of the B side can fortunately be readily obtained mathematically.

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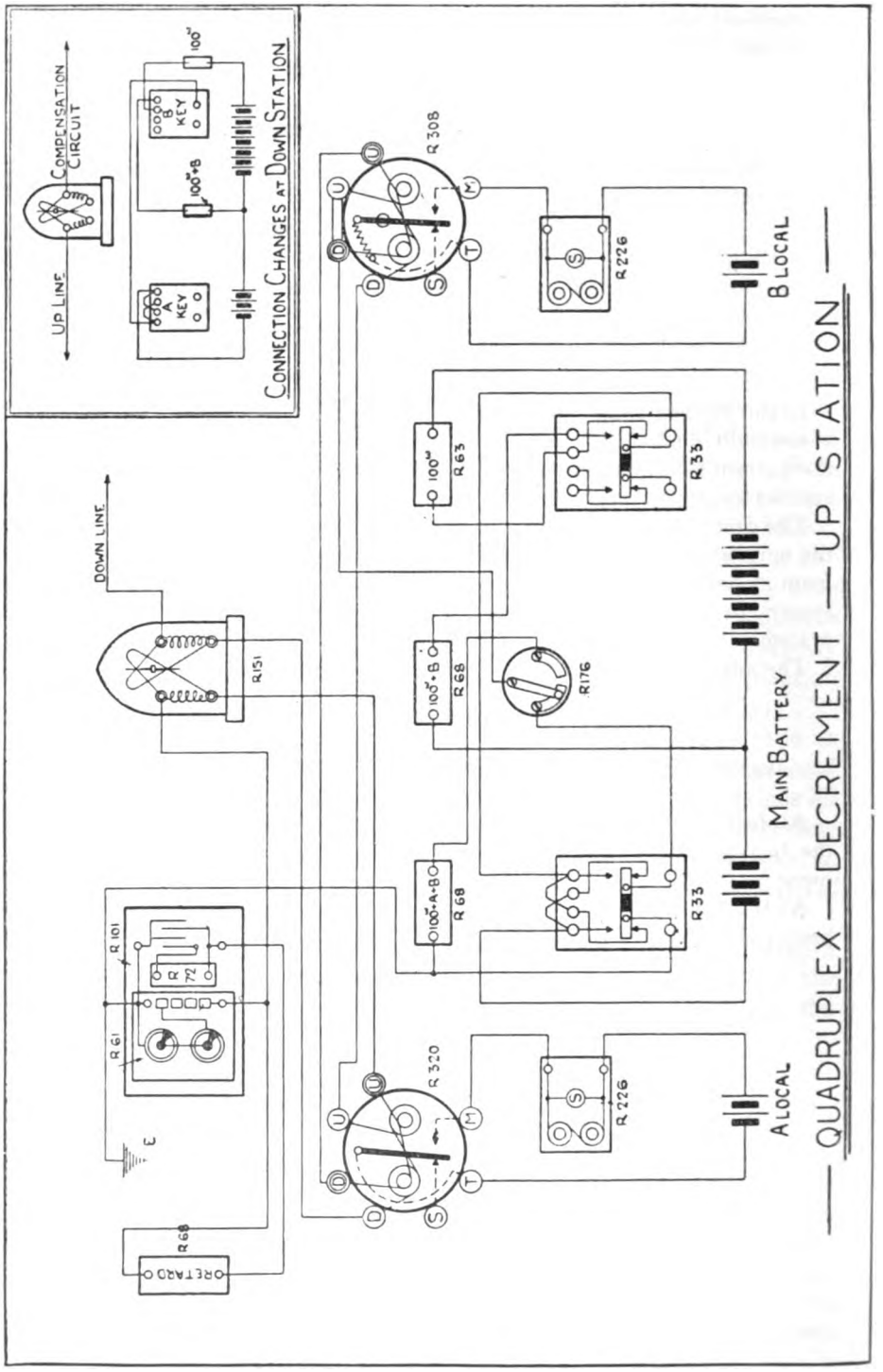

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The local circuit is shown diagrammatically in *Fig.* 1. The sounder is joined up in series with a resistance varying from 100 to 700 ohms and a battery of 40 volts, the sounder and the variable resistance being shunted by a condenser of 8 mf.

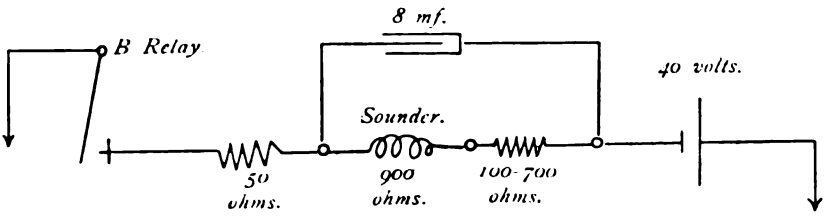

FIG. 1.

The small resistance of 50 ohms is provided in order to prevent the relay contacts from welding during the charging of the condenser. It is not required if the battery possesses internal resistance.

The function of the condenser, as is obvious from the diagram, is to supply current to the sounder during the short interval of time that the tongue of the B relay is away from the marking contact when the A key reverses the direction of current in the line, and the capacity of the condenser is of such a value as to furnish a quantity of electricity which will provide a current of the necessary magnitude to flow through the sounder and maintain the magnetic flux for the desired time.

Two current values have to be considered, (*a*) that from the condenser discharging through the sounder and resistance in series with it, and (*b*) the current due to the self-induction of the sounder itself which passes through the resistance and capacity. They are obtained as follows.

From the equation for current :—

$$\frac{d^2i}{dt^2}+\frac{R}{L}\frac{di}{dt}+\frac{1}{LK}i=\frac{1}{L}f'(t)$$

when $f'(t)=0$, the solution when RK is greater than 4L is well known to be :—

$$i=e^{-R/2L.t}(A\sin\theta+B\cos\theta)$$

or

$$i=Ae^{-R/2L.t}\sin\left\{\frac{(4LK-R^2K^2)^{\frac{1}{2}}}{2LK}t+\phi\right\}$$

A and ϕ being arbitrary constants of integration

where A stands for $(A^2-B^2)^{\frac{1}{2}}$

and ϕ „ „ $\tan^{-1}B/A$.

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At the time $t = 0$, the following values obtain, $i = 0$, $\phi = 0$ and

$$A = \frac{2Q}{(4LK - R^2K^2)^{\frac{1}{2}}}$$

Consequently the current from the condenser is

$$i_k = \frac{2Q}{(4LK - R^2K^2)^{\frac{1}{2}}} e^{-\frac{R}{2L}t} \sin \frac{(4LK - R^2K^2)^{\frac{1}{2}}}{2LK} t$$

By substituting in the above equation the following values which relate to apparatus actually in use,

$$Q = KV = 8 \times 10^{-6} \times 40 \text{ coulombs}$$

$$L = 20 \text{ henries}$$

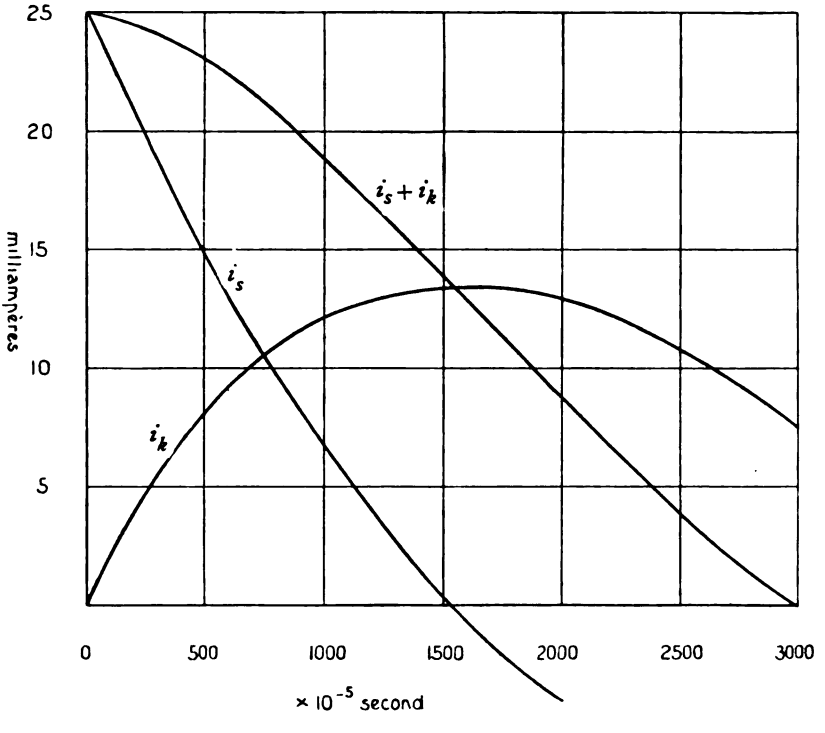
$$K = 8 \times 10^{-6} \text{ farads}$$

$$R = 1600 \text{ ohms.}$$

The result is obtained :—

$$i_k = 29e^{-40t} \sin 68.1\, t \text{ milliamperes.}$$

The current due to the inductance of the sounder may be obtained thus.



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From the similar equation for quantity of electricity

$$q = A_1 e^{-\frac{R}{2L}t} \sin \left\{ \frac{(4LK - R^2K^2)^{\frac{1}{2}}}{2LK} + \phi' \right\}$$

it is seen that $q = 0$, and $\phi = 0$, at the time $t = 0$.

By differentiation of the above equation and by substitution, the current due to the inductance of the sounder is obtained, namely,

$$i = -I \sqrt{4LK/(4LK - R^2K^2)}\, e^{-\frac{R}{2L}t} \sin \left\{ \frac{(4LK - R^2K^2)^{\frac{1}{2}}}{2LK} t - \phi \right\}$$

and when the constants of the apparatus already given are substituted

$$i_s = -29e^{-40t} \sin (68.1t - 59.583^\circ) \text{ milliamperes.}$$

The total amount of current in the sounder is $i_k + i_s$, and these calculated values are shown on the attached table, and graphically on the curves.

QUADRUPLEX (INCREMENT SYSTEM).

Current in Sounder when "B" Relay Contact Broken.

Time second.	Current due to Inductance of Sounder = i_s mas.	Current due to Condenser = i_k mas.	Total Current in Sounder = $i_s + i_k$ mas.
0	25	0	25
5×10^{-5}	24·92	0·101	25·021
10×10^{-5}	24·82	0.2018	25·0218
100×10^{-5}	23·02	1·896	24·916
200×10^{-5}	21·03	3·632	24·662
400×10^{-5}	17·16	6·645	23·805
600×10^{-5}	13·46	9·06	22·52
800×10^{-5}	10·00	10·9	20·9
1000×10^{-5}	6·835	12·22	19·055
2000×10^{-5}	−4·139	12·75	8·611
3000×10^{-5}	−7·335	7·75	0·415
4000×10^{-5}	−5·808	2·362	−3·446
5000×10^{-5}	−2·746	−1·038	−3·784

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Colonel A. W. Baird, C.S.I., F.R.S.,

Late Royal Engineers.

(Taken about 1896).

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MEMOIRS.

COLONEL ANDREW WILSON BAIRD, C.S.I., ROYAL ENGINEERS.

By COLONEL R. H. VETCH, C.B.

COLONEL A. W. BAIRD was descended from a younger son of the family of Baird of Auchmedden. His great grandfather, Charles Baird, settled in Aberdeen as a manufacturer, became a man of some importance and influence in that city, and was one of the first in Scotland in the 18th century to erect machinery, imported at great cost from England, in his mills. At a later date, when early in the 19th century Napoleon Bonaparte threatened to cross the Channel and invade England and a large British Volunteer Army was formed to oppose him, Charles Baird showed his patriotism by raising a company of Volunteers in Aberdeen. He married Jean, daughter of John Matheson, of Bennetsfield, Ross-shire, who claimed to be chief of the Clan Matheson, and by her had a family of five sons and two daughters. He died in 1836. One of his daughters married Capt. Mason of Leith, and their daughter Agnes Scarth Mason was the first wife of Sir Fitzroy Kelly, the last Chief Baron of the Exchequer of England.

Charles Baird's youngest son Thomas, born in 1794, grandfather of the subject of this Memoir, married a Miss Hay, sister of Major Patrick Hay, who fought as an ensign in the 42nd Highlanders at Waterloo and died some years afterwards in Madras. By her he had a small family; he was suddenly seized with cholera at Fortrose, Ross-shire, in September, 1834, and died after an illness of six hours at the age of 40, leaving a son Thomas, born in 1820, and not yet 14 years old, to meet great financial losses. Thomas Baird, of Woodlands, Cults, Aberdeen, went into business when he was 16 years old and eventually became very prosperous. Marrying Catherine Imray he had a family of nine childern—five sons and four daughters—several of whom died in infancy.

The eldest son of this family was ANDREW WILSON BAIRD, born at Aberdeen on the 26th April, 1842. Educated at the Grammar School and at Marischal College, Aberdeen University, where, having been for some years a pupil of Dr. Rennet, the well-known mathematical tutor in Aberdeen, he showed distinct mathematical talent and

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carried away several prizes. A nomination was procured for him to a cadetship at the "Military Seminary," as it was officially called, of the Hon. East India Company at Addiscombe and he joined the College in June, 1860. In January of the following year he was transferred to the Royal Military Academy at Woolwich, on the amalgamation of the Indian Army with the Royal Army and the consequent closing of Addiscombe College. He received a commission as lieutenant in the Royal Engineers on the 18th December, 1861, and joined at Chatham in the following February for the usual course of professional instruction.

Sailing for India on the 1st March, 1864, Baird was at first employed as Special Assistant Engineer of the Bombay Harbour Defences. He had charge of the construction of the batteries at Middle Ground and Oyster Rock until the end of 1865, and was then appointed Special Assistant Engineer of the Government reclamations of the harbour foreshore. It was a time of great commercial excitement and speculation in Bombay. Shares in the various improvements of the harbour and city were in demand, particularly the Back Bay reclamations which were at their height. He had great temptations thrown in his way to speculate but although young he had a cool head and his character was strong enough to enable him to avoid these pitfalls.

In 1868 Baird was ordered on active service and appointed Assistant Field Engineer in the Abyssinian Expedition under Major-General Sir Robert Napier, afterwards Field Marshal Lord Napier of Magdala. Arriving at Zula, Annesley Bay, the port of disembarkation in Abyssinia, on the 28th February, he was at once attached to the railway department and appointed traffic manager of the railway then being constructed from the base at Zula to the camp formed at Kumeyli at the foot of the hills 10 miles away. The actual work was executed by men of the 23rd Punjab Pioneers and 2nd Bombay Grenadiers, but the officers who superintended the construction, maintenance and working of the line were Capt. Darrah, and Lieuts. Willans, Pennefather, and Baird, all of the Royal Engineers. The devotion to duty shown by these officers on the railway, early and late, day by day, for upwards of five months under most trying circumstances of climate was acknowledged by the Commander-in-Chief in his despatch, and Baird as traffic manager was especially mentioned for his conduct of the troops and baggage to the base at the termination of the successful campaign (*London Gazette*, 30th June, 1868). Baird received the war medal for his services. On his return to Bombay he was retained until the end of November in the Military Department to wind up the accounts of the Engineer Park.

Appointed Assistant Superintendent in the Great Trigonometrical Survey of India in December, 1868, Baird was employed successively on the triangulation of the districts of Kathiawar and of Guzerat. He suffered much from the extreme heat of that arid country and in

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the spring of 1870 he was compelled to take leave of absence to England. His zeal and accuracy in scientific work had become well known to Colonel (afterwards General) J. T. Walker, the Surveyor-General of India, and while both Baird and Walker were on furlough in England in 1871–2 Baird was selected by the Secretary of State for India, on Colonel Walker's recommendation, for special duty in connection with scientific research as to tidal observations. In the first instance tidal observations were only undertaken by the Survey of India with the object of determining the mean sea level as a datum for the Trigonometrical Survey. The first observations were of a very imperfect character, and it was not until 1855 that a self-registering tide gauge was used and even then the observations were restricted to a month in duration.

In a preface to his valuable *Manual of Tidal Observations* Baird himself gave an account of the origin of the Tidal Survey which may be summarized as follows. Subsequently to 1855 it was desired to investigate the relations between the levels of land and sea on the coasts of the Gulf of Cutch, which were believed by geologists to be gradually changing. This necessitated a more exact determination of the mean sea level than had hitherto sufficed for the operations of the Survey. While Colonel Walker was at home he found that a committee of the British Association presided over by Sir William Thomson, afterwards Lord Kelvin, was engaged in initiating a system of tidal investigations which it was anticipated would secure results of the highest value. He decided to have observations made at stations in the Gulf of Cutch, in accordance with the system proposed by this committee, by self-registering gauges set up for at least a year to determine the existing relations of land and sea, and again for another year when a sufficient interval had elapsed for a sensible change to have taken place. Baird was deputed to study the details of tidal registrations and the reduction of observations by harmonic analysis in accordance with the method suggested by Sir William Thomson and his committee. He made arrangements to secure self-registering barometers and anemometers to indicate the atmospheric conditions prevailing at each tidal station as it was most necessary to record them concurrently with the changes of sea level. He tested at Chatham a new self-registering tide gauge constructed by Adie and, in December, 1872, went to India and made a reconnaissance of the Gulf of Cutch.

Visiting first Juria Bandar, close to the head of the Gulf, he there fitted up a country boat for navigating the creeks and channels of the Gulf, and secured the services of an experienced pilot to accompany him in his explorations. After a month's cruising about and long searching along the muddy shores of the Gulf three places well adapted for tidal observations were found and were, indeed, the only places that would have answered the requirements. His instructions

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to establish a station "at a point as far into the Runn of Cutch as possible to which the tide has free access" meant that the point selected must always have at least 4 or 5′ of water over it at lowest tides, and also that the sea should approach it directly and not by tortuous channels. Such a position was found at Hanstal Point at the head of the Gulf, 18 miles from Juria; a second point he chose was Nawanar midway up the Gulf on the Cutch coast, 15 miles from Mudra; and a third at the mouth of the Gulf was Okha Point on the Kathiawar coast, opposite the island of Beyt. The observatories and their accessories having been established required periodical inspection and Baird and his assistant visited them turn about. Native subordinates were placed in charge of the instruments and provided with huts and water tanks and a guard at each station; a line of post runners was arranged to the nearest postal communication and daily reports were sent to Baird by the men in charge of the observatories.

The inspections entailed a great deal of hard marching and necessitated exposure, privation, and some risk. Even as early as in the month of May before the setting in of the monsoon, the Runn of Cutch was covered with water, from 6″ to 1′ in depth, which had to be waded through for many miles to reach the station at Hanstal. Camels of the country, accustomed to wading and very sure footed, were used. Of one of his journeys to Hanstal Baird wrote: "Our only landmarks in the whole of the last 14 miles were two small mounds of earth thrown up—when there were postal chowkies there—at 4 or 5 miles apart, and the observatory itself; we felt a curious sensation as if we were being carried out to sea, which was occasioned by seeing small branches of scrub floating on the surface of the water and being driven by the wind inland; and once, with the exception of one of the mounds above mentioned in the distance, there were no fixed objects visible to destroy this optical delusion."

It may here be mentioned that the three stations in the Gulf of Cutch, having been reopened after a long interval, the previous mean levels have been ascertained to be virtually unchanged.

Baird was promoted to be captain on the 4th April, 1874. Two years later he received the commendation of the Governor-General in Council for his successful labours and in July, 1877, instructions were promulgated for the establishment of systematic tidal observations at all the principal Indian ports and at certain other ports on the coast lines where results might be obtained which would be of general scientific interest, apart from their practical usefulness in affording data for the calculations of the rise and fall of the tides and for the construction of tide tables for the purpose of navigation. By direction of the Government of India the general superintendence—under the Surveyor-General of India—of tidal observatories was entrusted to Baird, who by that time had attained the grade of Deputy Superintendent in the Great Trigonometrical Survey Department.

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In the meantime Capt. Baird had been sent home in 1876 with his observations in the Gulf of Cutch, and had worked out the results with the assistance of Mr. Roberts, of the *Nautical Almanac* Office. In the autumn of the year he read a paper on "Tidal Operations in the Gulf of Cutch" before the British Association at Glasgow. On his return to India in 1877 he organized in accordance with the instructions of the Government of India an entirely new department of the Survey, spread along the coast lines from Aden to Rangoon with its centre at Bombay. "Perhaps," says Sir George Darwin, who first met Baird in 1882 at Lord Kelvin's house and was for the next three years in constant communication with him, "the most convincing proof of the care and foresight with which the tidal department was founded is afforded by the fact that there is nothing to record as to its subsequent career, but it is obvious that the work demanded, and still demands, constant attention to scientific details" (Obituary Notice, *Proceedings of the Royal Society*).

Four years later in the summer of 1881, Capt. Baird was sent to Venice by the Government of India as one of the Commissioners to the Third International Congress of Geography. The other Commissioners were General Sir H. E. L. Thuillier, C.S.I., and Lieut.-Colonel C. T. Haig, R.E. The preparations for the proper display of the Indian collection were made by Lieut.-Colonel Haig and Capt. Baird. Among the exhibits of the Indian Survey was the new self-registering tide gauge which formed a special object of interest.

In his report to the Government Sir Henry Thuillier says: "It was at work daily showing the tidal courses in the adjoining canal and, as so well explained by Baird, was one of the most successful sights in the entire exhibition, and eagerly enquired after and studied by the Venetians as well as other foreigners . . . Major Baird [he was promoted major on the 18th December, 1881] was peculiarly happy with his new tidal gauge, which I may say formed one of the very chief attractions of the meeting. To this officer is due equal credit with Colonel Haig for unremitting attention, and the most successful efforts in causing everything to go off well, whilst his social relations with the numerous foreigners with whom we were so constantly in contact, and his general happy disposal of every transaction with the General Committee of the Congress, calls for my unqualified praise and entitles him to much credit." Baird was awarded the Gold Medal of the 1st class for his work in connection with tidal operations and he received the thanks of the Government of India and the Secretary of State for his services at Venice.*

° *See* Report of the Terzo Congresso Geografico Internazionale tenuto a Venezia, 1881, pp. 237–8; also *Proceedings of the Royal Geographical Society*, December, 1881; and Blue Book, Government of India, Revenue and Agricultural Department, "Exhibition," 1882.

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From Venice Baird went to England on furlough and in May of the same year he became an Associate Member of the Institution of Civil Engineers. In December, 1882, he was elected a Fellow of the Royal Geographical Society. Returning to India in March, 1883, Major Baird resumed charge of the Tidal and Levelling Department of the Survey, his area of operations including India, Burma, Ceylon and the Andaman Islands.

On the 27th and 28th August of the same year the great volcanic eruption in the island of Krakatoa in the Straits of Sunda caused a wave which was distinctly traceable in the majority of the tidal diagrams and a paper on the subject by Major Baird was published in 1884 by the Royal Society (see *Proceedings*, No. 229, 1884). Writing to Professor (afterwards Sir) G. H. Darwin from Poona on the 27th September, 1883, Baird said:

"The wave caused by the volcanic eruption at Java is distinctly traceable on all the tidal diagrams hitherto received and I am informed of great tidal disturbance at Aden on August 27th; but the daily reports are always meagre in information. Karachi and Bombay also show the disturbance, and as far as I have examined, the wave reached halfway up to Calcutta on the Hugli. . . .

"Negapatam was most disturbed and at Port Blair there was very great disturbance. I have reports from Port Blair of tremendous noises as if a ship were firing guns as signals of distress, and they sent out a steamer to look about. Similar reports come from the Nicobars. . . . "

In May, 1885, Major Baird was elected a Fellow of the Royal Society for his work on the tidal operations in India and Burma.

From July, 1885, to August, 1889, Major Baird acted on different occasions for some months at a time as Master of the Mint at Calcutta and also of that at Bombay during the absence on furlough of the holders of those offices. On other occasions he officiated for the Assistant and Deputy Surveyors-General of India. He was promoted to be brevet lieutenant-colonel on the 18th December, 1888, and on the 12th August, 1889, was appointed Mint Master at Calcutta, a post he held until his compulsory retirement from the Service, which took place in accordance with the regulations at the age of 55 years on the 26th April, 1897. In the meantime he had been promoted regimental lieutenant-colonel on the 9th April, 1891; brevet colonel on the 29th September, 1893; and substantive colonel on the 9th April, 1896.

During the eight years that Colonel Baird was at the head of the Calcutta Mint he carried out almost a complete reorganization of the manufacturing department, which resulted in both increased efficiency and economy. In 1895—1896 the Government of India directed him to enquire into the state of the coinage of India, which was becoming so seriously worn that it was necessary to withdraw some of the

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older issues from circulation. In his report* Colonel Baird dealt elaborately and scientifically with the average annual wear of the rupee and of the smaller coins, as well as with the mean annual accretion of dirt on the old coins, which was almost proportional to the age of the coin. He also at some length discussed plans for the withdrawal of the old coins from circulation. The Government adopted most of his suggestions and it was in consequence of his work that the coinage was established on a satisfactory footing.

Although it was proposed by the Government of India to grant an extension of service as Master of the Calcutta Mint to Colonel Baird he felt obliged to decline the offer. After many years' service in India, the climate was beginning to tell upon his health and he was anxious to settle down at home with his family. In acknowledging the receipt of his final report on the Calcutta Mint, dated 11th March, 1897, the Secretary to the Government of India wrote on the 29th April following that the Governor-General in Council desired him to convey to Colonel Baird the special thanks of the Government of India for his valuable services both as Mint Master at Calcutta and also throughout his employment in India. Colonel Baird was created a Companion of the Order of the Star of India in June, 1897.

The Plumian Professor of Astromony and Experimental Philosophy at Cambridge at the close of his obituary notice of Colonel Baird in the *Proceedings of the Royal Society*, 1908, has written of Baird and his work in India in the following terms: "It is on such men as Baird and on such unwearying services as those sketched above that the administration of the Indian Empire depends. . . . In science he has left a permanent mark as the successful organizer of the first extensive operations in tidal observations by the new methods. The treatment of tidal observations is now made by harmonic analysis in every part of the world, and this extensive international development is largely due to the ability with which he carried out this pioneer work in India."

Leaving India for good in 1897 Colonel Baird returned home and bought a small property, Palmer's Cross, near Elgin. His health gradually became very delicate and he frequently passed the winter abroad in warmer climates. His death was sudden, the result of heart failure, and took place on the 2nd April, 1908, while he was on a visit to London with his wife and daughters, at 23, Bentinck Street, W. His remains were buried at Highgate Cemetery on the 6th April.

Colonel Baird married at Aberdeen on the 14th March, 1872, Margaret Elizabeth, only daughter of Charles Davidson, of Forrester Hill, Aberdeen, by his wife, Jane Ross, and sister of Major G. Davidson,

* No. 278, dated 17th March, 1896—"From Colonel A. W. Baird, R.E., F.R.S., etc., Master of the Mint, Calcutta, to the Secretary to the Government of India, Finance and Commerce Department."

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R.E. (Retired List). She survives him with a family of two sons and five daughters. The elder son, Percy Thomas Charles Baird, born in 1872, is a captain in the Queen's Own Cameron Highlanders; the other son, Harry Beauchamp Douglas Baird, born in 1877, is a captain in the 12th Cavalry, Indian Army, and Brigade Major to the Inspector-General of Cavalry in India. The second daughter married, in 1906, Captain Hugh de B. Miller, D.S.O., Royal Field Artillery; and the third daughter married, in 1908, Captain H. S. H. Richmond, Royal Marine Light Infantry.

Colonel Baird was the author of the following works:—"A Manual of Tidal Observations and their Reduction by the Method of Harmonic Analysis," 1886*; articles in the *Bombay Gazetteer* on the Gulf of Cutch, Little Runn and Gulf of Cambay; Notes on the Harmonic Analysis of Tidal Observations, published by order of the Secretary of State, 1872; Paper read before the British Association in 1876 on the Tidal Observations of the Gulf of Cutch†; Auxiliary Tables (two pamphlets) to Facilitate the Calculations of Harmonic Analysis of Tidal Observations, 1879 and 1882; Account of the Tidal Disturbance caused by the Volcanic Eruption at Krakatoa (Java), August, 1883, *Royal Society Proceedings*, 1884; Joint Report with Professor G. H. Darwin of the Results of the Harmonic Analysis of Tidal Observations, *Royal Society Proceedings*, March, 1885; Account of the Spirit Levelling Operations of the Great Trigonometrical Survey of India, British Association, 1885‡; Tide Tables for Indian Ports (annual) jointly with Mr. Roberts, of the *Nautical Almanac* Office.

"Baird," says one who knew him, "was of an upright and lovable character, and of a very generous and genial disposition."

Another writes: "Baird was always a steady and careful worker and however employed—whether on the reclamations in Bombay, on the Trigonometrical Survey of India, or finally as Master of the Mint in Calcutta—his whole heart was in his work. The care and forethought he exercised in the preparations for his tidal observations, by which every difficulty that might arise was forestalled, enabled him to obtain results of great scientific importance. . . . He was a good genial companion and a true and sincere friend. His sympathetic and kindly nature disposed him to view with leniency the faults of those with whom he came in contact and his dealings with all were scrupulously just."

Another friend writes: "Baird I knew for over 20 years and in him

* Published by Taylor & Francis at the expense of the British Association. It contains a valuable account of practical experiences together with full instructions for the application of the harmonic method of reduction.

† This paper was reprinted in the *Royal Engineers Journal* for October, 1876.

‡ Also printed in Supplementary Papers of the Royal Geographical Society.

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I lost one of my dearest friends. I first met him in Calcutta and I remember I was speedily attracted by his personality and presence. As I got to know him better and to perceive the many fine traits in his character, feelings of respect and affection were engendered in me and these last grew deeper as years passed by. He was a truly loyal friend with a very sympathetic heart which made him always very sensitive and quickly responsive to all that affected or concerned his friends. His sense of duty and of honour was very high, and considering his achievements he impressed me as being so modest."

One who worked with Baird as a colleague in the last official post he held in India, the Calcutta Mint, and who knew him for many years in family life and as a member of the same club has written an appreciation of his friend, from which the following extracts are taken :—

"His nature was evidently and truly charitable. When conversing with him about acquaintances or men of the day it was remarkable how much praise he had in store for an enormous percentage of them. He seemed singularly free of jealousy regarding promotions, rewards and decorations. On the rare occasions when someone was mentioned whom he could not conscientiously praise he would endeavour to change the topic; or if compelled to admit that some individual had mismanaged a certain piece of work, he would strive to show that in some other direction the same person had done really well.

* * * * *

"In club life the general verdict of the members of all ages was that he was 'a good fellow.'

"He was always very much in earnest over his Mint work and constantly strove to make improvements, most of which, from their nature could not redound to his credit outside the walls of the Establishment. . . .

"The writer often had occasion to admire the orderly and methodical habits of his late friend. His notes on the work he was engaged in were so handy and well arranged that he could refer to them with the least possible delay. He never had to make the common remark—'I have a note on the subject somewhere, but do not know where to lay my hand on it just now.' On an occasion when Baird contemplated an excursion to a distant part of the Himalayas with a rather large party, the writer found that he had, by consulting time tables, guide books, and so forth, drawn up an admirable programme showing dates, special articles to be taken, etc., etc., with a most useful estimate of the probable cost of the whole trip. How much petty trouble must have been saved in this way!

"Baird always shone when asked by friends for advice and help. On such occasions he seemed possessed of a feverish anxiety to do everything he possibly could, and never to let the thought of trouble obtrude. . . .

"His disposition was eminently fair as what follows may illustrate. He and a certain colleague had a difference of opinion about their official relation to one another, and Baird determined to refer the point to

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superior authority. When he had composed his letter he sent it to the colleague for perusal and remarks, adding that if the colleague particularly wished it he would drop the matter. The colleague thought the case had been fairly stated. The reply from superior authority was to the effect that there seemed to be no occasion for making a change in the established relation. Baird at once loyally accepted the ruling, and during a long subsequent collaboration never showed any desire to get it altered. Indeed, pushing the matter to its logical conclusion, he sought to bring his colleague more prominently forward. This he did by more frequent consultation, by suggesting joint reports when views had to be given by both on the same subject, and in other ways. Here there had been an appeal to the umpire and the decision had been given against Baird. He accepted it thoroughly in the spirit of a true sportsman."

The above Memoir is founded partly on information supplied by Mrs. Baird; partly on Colonel Baird's own publications; an article on him in *Men and Women of the Time*, 1891; a Memoir by Professor Sir G. H. Darwin in the *Proceedings of the Royal Society* and a Notice in the *Proceedings of the Institution of Civil Engineers*, Vol. 172, Part II.; the Obituary Notice in *The Times*, 10th April, 1908; *Journal of the Asiatic Society of Bengal*, Vol. 47, 1878, Part II.

The portrait is from a photograph taken in India when Colonel Baird was Master of the Calcutta Mint.

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was most extraordinarily (almost uncannily) accurate. The result was that the Staff felt, and knew by experience, that, if Irvine said he would make a bridge in a certain time, they knew they could absolutely rely on him, and that he would never play them false by wrong or misjudged estimates of time. And the absolute reliance, which the Staff thus learnt to place in him, earned not only him, but also "A" Troop, a reputation second to none in Buller's Natal Army."

Major-General H. M. Lawson, who was in the same batch with Irvine, adds the following note :—

"I can corroborate what is so well written above. When I joined the Headquarter Staff of the Natal Army directly after the relief of Ladysmith, nothing of what I heard from my comrades on the Staff struck me so much as the unstinted praise bestowed on Irvine and the Pontoons. This feeling too went far beyond the mere Staff. The army that relieved Ladysmith was essentially one of brave deeds and brave men, but no body of men in it bore a higher or better recognized reputation for courage and devotion than did the Pontoon Troop and its commander.

"Irvine's name was on so many people's lips in those days, and it would be difficult to exaggerate the high reputation that he enjoyed. This was due, much to what the previous notes have described, and much also to an unfailing modesty, cheerfulness, and readiness. Irvine could never make a difficulty, no day and night was too long for him and his men, and fresh obstacles only spurred him to greater efforts. Of him the old saying is especially true 'He never said he wouldn't, or he couldn't, or he didn't know how.'"

Irvine, in the minds of all those who served with him, will always remain connected with Aldershot. His early days were spent there, it was the place where he acquired the love for riding and hunting which he ever retained, where the successes of his mare "Molly Bawn" are still remembered, where the N.C.O.'s and men and their families still speak affectionately of the kindly interest ever taken by him and Mrs. Irvine in their welfare. Those who saw him bravely battling for his life towards its end, know that his happiest recollections were of those days when he lived at Wood End, Farnborough, or at the house near the R.E. Mess, Aldershot, where he was in intimate touch with the Corps, into whose advancement he threw himself heart and soul.

Probably Irvine would have appreciated more than any other words, those in which a non-commissioned officer, who served under him for many years, spoke of him. "He was a first-class regimental officer and a thorough gentleman."

Irvine was married during the time he was in Bermuda to Miss Dora Louisa Gallwey, daughter of Lieut.-General Sir Thomas L. J. Gallwey, K.C.M.G., R.E., then Governor of the Island. His son has joined the Argyll and Sutherland Highlanders, in which his uncle Major Thomas Irvine served. "Laird" and "Tom" Irvine now rest side by side in the cemetery near Fort Pitt, Chatham.

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NOTICES OF MAGAZINES.

Giornale del Genio Civile.

August, 1911.

High Tension Transmission in America.—*Generators.*—These are generally alternators of 13,000 or 20,000 volts. Three-phase current is generally used (periodicity 25), the voltage varying with the distance, the usual tensions being :—110, 240, 1,100, 2,200, 3,300, 6,600, 11,000, 13,000. In illumination circuits round the works, the periodicity of 60 is also used.

Power Stations.—In the larger works, the generators are in a building by themselves the apparatus for measuring and distributing the energy being in a separate building connected to the first by means of a gallery which contains the cables carrying the electricity, in suitable concrete pipes. The electrician in the generator room has only to put the generators in circuit and take them out again. There is in the bigger works a small central observation post in which the electrician in charge of the switchboard sits, and from which he can watch the hands in charge of the various machines and panels of the switchboard.

Bus Bars.—The bus bars for the main switchboard are almost always supplied in double, but seldom are they in separate closed circuits; they are not divided into sections. There is not a circuit breaker between each machine and its feeder.

Switchboards.—Generally polished slate is used for the switchboard; it is mounted on angle or tube iron frames fixed directly into the ground. The apparatus concerning the exciters, auxiliary motors and accumulator batteries are on a separate switchboard.

Circuit Breakers.—Generally oil switches of 2,000 to 3,000 amps. at 2,500 to 15,000 volts are employed. They have proved very satisfactory, and require no special looking after. Switches of 60,000 volts have also been used for three years without any need to replace the oil. Tests have also been recently made with switches of 400 amps. at 110,000 volts. In smaller power stations air switches have been tried, they cost less but require a free space of 3 metres in height. Oil switches in which the breaking of the circuit takes place in a horizontal direction are preferred, as this enables the spark to be more easily put out.

Fuses.—These are only employed when air switches are in use.

Tension of Power Circuits.—The insulating materials used allow a tension of 110,000 volts. Efforts are being made to get insulators to stand a pressure of 200,000 volts, with more hope of success than existed a few years ago when they were looking for insulators to withstand 100,000 volts. There is actually at work at present a line 200 kilometres long on which a tension of 135,000 volts is used.

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Supports of Aerial Lines.—In districts where wood can be obtained posts 9 or 10 metres long are used; diameters at base and head are from 25 to 30 and 18 to 23 c.m. One-fifth to one-seventh of the post is buried in the ground. These posts are first of all put into cylindrical vessels, at a temperature of 100° to 120° Centigrade, then are placed in a second cylinder where there is a vacuum, to get all traces of moisture out of them, finally they are placed in a third cylinder where a very good disinfectant is put into them at the required pressure. The average life of these posts is 20 years for cedar wood, 15 for chestnut, and only 10 for fir or pine. If the part of the post in contact with the ground rots, it is sometimes surrounded with iron bars and the whole is covered in concrete. It is however always better to replace the post. The best procedure of all is to encase the base of the pole in concrete which comes at least 20 c.m. above the surface of the soil. Reinforced concrete posts are used where extra strength is desirable.

The general practice to-day is to employ iron girder work posts, with rectangular or square bases; U or T iron is generally employed. The height is about 14 metres, side of square at base 1·83 metres, depth buried in soil 1·52 metres, encased in concrete, average span 75 metres; for greater spans of 125 metres, posts of 19 metres are used.

The conductors are 12 m.m. in diameter and consist of seven steel wires. They are carried at the corners of an equilateral triangle of 2·13 metres side. The above figures refer to the lines of the "Ontario Power Company."

Protection.—Networks to protect telegraph or telephone wires from contact with high tension wires in case of breakage of the latter are rare, probably because they are not legally enforced.

Transformers.—Three-phase static transformers are used, it having been found more economical to use them than to use single-phase ones. In the case of small transformers, they are cooled by air and water circulation; in the case of larger transformers, forced ventilation is used. Star or triangle windings are used; it has been found that the star windings work better if the neutral point is connected to earth.

A. H. SCOTT.

RIVISTA DI ARTIGLIERIA E GENIO.

July—August, 1911.

ON THE IMPORTANCE OF AUXILIARY TECHNICAL METHODS IN ADVANCED RECONNAISSANCES.—In an article that lately appeared in the *Vierteljahrshefte für Truppenführung und Heereskunde*, 1911, the principal ideas on the subject mentioned above are explained by Major Thomsen of the German General Staff.

In advanced reconnaissances the cavalry in discovering the locality and movements of the enemy are always likely to come into contact with mixed detachments of the three arms which have been pushed forward

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on the enemy's front and flanks. To overcome such resistance it should be provided with power of fire that it does not possess in its present equipment; and even if it were provided with a rifle of equal power with the infantry, it would always find itself in a condition of inferiority, owing to the small numbers that would be found in the firing line, and also to the fact that the horses are an impediment to profiting by the advantages which might eventually be obtained.

Although the fire of the cavalry should be rapid and have the character of surprise, the idea now seems to be favoured of assigning horse artillery to the masses of cavalry in advanced reconnaissances, and also detachments of infantry and mitrailleuses which would give the necessary fire power, and which should possess such mobility as would not interfere with free movements, this can be obtained by automobiles and bicycles. Isolated detachments of cavalry should be employed between the patrols and squadrons; but between these and the commander of the cavalry on advanced reconnaissances the necessity will be felt of technical means of communication. The telegraph and the telephone are the technical means now in use, but the automobile and the motor cycle, movable stations for wireless telegraphy, and apparatus for visual signalling, are also now of the greatest importance. The automobile as a means for transporting fire power, as represented by rifles and mitrailleuses, is found to be ill adapted to this work; the heavy wagons for carrying 40 men with their arms and equipment, besides the mitrailleuses, are always tied to the roads, and have to be abandoned by the cavalry, thus losing that cohesion between the two elements which is so essential to success.

If however the cavalry regulates its movements to those of the column of automobiles, its action becomes restricted, especially in regions with a network of muddy roads, the freedom of its movements being hindered, which freedom constitutes the principal basis of its employment.

Again the idea of assigning to the cavalry on advanced reconnaissances armoured wagons with cannon, which, left on the roads, may be captured by the enemy's exploring parties, is shown to be impracticable, owing to their weight and inability to turn on ordinary roads. Means of this kind for transporting rifles and mitrailleuses on automobiles should not be assigned permanently to bodies of cavalry when employed on such service. There are also grave objections to the use of ordinary automobiles for exploring roads, etc.; such carriages pushed forwards in advance beyond our extreme lines would certainly be lost, either by capture by the enemy in the vicinity, or by the drivers being struck by projectiles; so that it may be impossible under the enemy's fire either to advance or to recede. It is therefore necessary to abandon the illusion that automobiles can be of great service for reconnoitring the roads, and to avoid the assignment of such vehicles to the cavalry commands. There is, however, a large scope for the employment of automobiles on advanced reconnaissances as a means of transport for the reinforcements for the masses of cavalry in poor and exhausted countries. The reinforcement at great distances from the depôts is a matter of great difficulty and inconvenience with long and slow columns of wagons drawn by horses, which seriously impede the movements of the cavalry.

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The employment of autocars of medium weight that would carry a useful load of 2 to 3 tons, and with a speed of about 15 k.m. would seem destined to effect a complete change in a remodelled service. The automobile is also an effective means of communication between the command of the cavalry and that of the army; an encounter with the enemy being exceptional in this case. In an enemy's country the hostility of the inhabitants may cause difficulty, but on the other hand the possibility of communication in a short time, between two commands at a distance, is of the greatest importance.

The substitution of the motor cycle for the automobile is not advisable; the working of the motor is not always reliable, and the motor cycle is too much affected by the state of the weather and of the roads, and calls for an extraordinary tension of the faculties of the motor cyclist, the only advantage offered is that it is able to pass long columns easily on the march. The bicycle however is well adapted for the transport of rifles, and for following the cavalry on advanced reconnaissances. The simplicity and the lightness of this machine gives to the cyclist detachments a mobility which enables them to keep in close touch with the cavalry wherever they go.

The telegraph and the telephone are the means of communication most in use, and the cavalry in advance should be well provided with the necessary material. Now, it may be observed that in war time the long lines of wire which constitute the communications are exposed to damages which may compromise the security of the latter; the employment of permanent lines such as those used in peace manœuvres, is only permissible in a friendly country. In an enemy's country the permanent lines would be destroyed and any repairs that could be executed would always be liable to interruption by the hostile population.

The apparatus for visual signalling does not present such inconveniences as those caused by the use of flying lines of telegraph wire, but it is necessary to establish a series of intermediate stations for the transmission of telegrams to great distances, and their use is much influenced by atmospheric conditions. Notwithstanding the above, this system is much favoured on account of its simplicity and facility of transport which permits of its use between the various lines of the exploring cavalry. The movable radio-telegraph system does not answer entirely to the above idea; the mobility which is required has not yet been obtained together with sufficient power, and the employment of stations transported by wagons and automobiles limits the communication between the commands of the cavalry and the supreme command.

In conclusion, in considering the three rôles of cavalry on advanced reconnaissances, fire power, mobility, and adaptability for transmitting information, we find that the first may be obtained by arming them with the best firearms existing, and by assigning to them detachments of trained mitrailleusists, and cyclist detachments, in addition to the horse artillery: the second may be increased by the exclusion of cars or wagons that tend to restrict them to the roads, so becoming an impediment, and by assigning automobiles only for the transport of reinforcements; and the third may be favoured by the use of wireless telegraphy, and visual signalling which would render them independent of telegraph lines.

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The successes obtained by dirigibles have given rise to the idea that the perfecting of this technical branch would not only be a complement to the explorations of the cavalry but would tend to a diminution of that arm. But this idea is not correct, because the great mass of cavalry in advanced reconnaissances does not only fulfil the duty of distant exploration, it serves also as a powerful means of protection to the army; the fact that the cavalry has to perform its duty during and after battles is of such importance as to exclude the idea of reduction of any kind.

But again let us consider how in carrying out distant explorations the cavalry is indispensable, whatever progress may be made in aerial navigation. Only by the aid of cavalry will it be possible to keep in touch with the enemy at night and in mist, and in all other cases when the action of the dirigibles or aeroplanes will be impeded by natural causes which will always exist.

Notwithstanding the difficulties of keeping account of all the factors which influence the action of the dirigible (force and direction of the wind, ascending and descending currents, variation of temperature, mist, rain, snow, etc.) it has to be considered that a dirigible of the latest model can under particularly favourable circumstances, make a flight of 250—300 k.m. in about 10 hours at a height of 1,200—1,500 m.

From observations made of the atmospheric conditions of Central Europe it would seem that similar conditions prevail only in a limited number of days of the year, so that the activity of the dirigible, especially in the spring or autumn, may be completely paralyzed for whole weeks.

Another difficulty in the employment of dirigibles for exploring purposes, is the necessity of having to keep up the hangars. The stations on the borders of the frontier would only serve for the first few days of a campaign, and the problem of adapted roofs, easily removable and transportable, is still far from being satisfactorily solved.

The principal advantages of the aeroplane consist in its simplicity and the small number of persons required for its preparation and manœuvring, and the possibility of preparing a great number in a relatively short time is of great value. The rapid flights which have recently been performed have also to be considered, sometimes more than 100 k.m. in the hour, and this last is of especial value in a military point of view.

The first natural consequences that aerial exploration will cause in a campaign will be the discovery and location of the enemy's troops, of their cover, and concealed trenches, etc.

Finally it may be observed that in increasing and bringing to perfection the means of exploration and communication it is impossible for the commander to avoid all uncertainty, and strong as the temptation may be to await new information, and to retard the sending of orders or despatches until a fortunate flight may clear up any doubt as to the enemy's position, such temptation would only suggest weakness. To command is so to speak to foresee, and when information is wanting, according to Clausewitz recourse should be had to the law of probability. In any case the commander ought to act, and not to leave the initiative to the enemy,—in action comes success, in inactivity defeat.

E. T. THACKERAY.

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CORRESPONDENCE.

TACTICAL RECONNAISSANCE.

SIR,

At a tactical reconnaissance tour carried out recently in the Lake District by two batches of young officers, the enclosed report was handed in by 2nd Lieuts. W. W. Peache and K. D. Yearsley.

As the report so thoroughly fulfils the requirements for which it is intended, the Commandant, S.M.E., thinks that its publication would be of general interest to the Corps and he trusts therefore that you may be able to find space for it the *R.E. Journal.*

Yours faithfully,

H. W. WEEKES,

Brigade-Major.

S.M.E., Chatham.

SCHEME.

Report on the road between Portinscale and Buttermere with a view to the retirement of the artillery from the right of the position by this route.

What can you do to improve it with your section of the 55th (Field) Company?

REPORT.

Ref.—Sketch Map Attached.

(1). The road from Portinscale to Stair (A5) being steep in places (1 in 8), we considered the advisability of going round by Braithwaite: but we considered that this road would be required for troops retiring by the Whinlatter Pass; so we have not reported on it. Also the Braithwaite-Stair road would be more exposed to hostile artillery from the east of Keswick.

(2). From Portinscale to Stair the road is well covered from view by woods. The metalling is good, and there are stone walls which could be broken up, in case of a bad fault in the road. Slopes of 1 in 12. (See sketch).

(3). Just after Stair there is a bad hill (1 in 8 for 150 yards), width only 8′. At the top the road is flat for 300 yards and about 20′ wide.

The upper part of the hill and the flat at the top are exposed to the enemy's artillery positions above Keswick.

This is the only portion of the road which is exposed.

(4). Some mounted infantry near Cat Bells (C6) would be all that would be required to protect the retirement. Their horses could be placed near Little Town (B6); and they could follow the artillery over the pass.

(5). The next difficult place on the road is the hill after Newlands Hotel (B5). About 300 yards of 1 in 10. If extra horses were required they could be sent back by the track in Newlands Valley (B4).

There is a sharp corner with deep slope (1 in 13) at Baird Hall (A—B4). This could probably be rushed as the road is 16′ wide.

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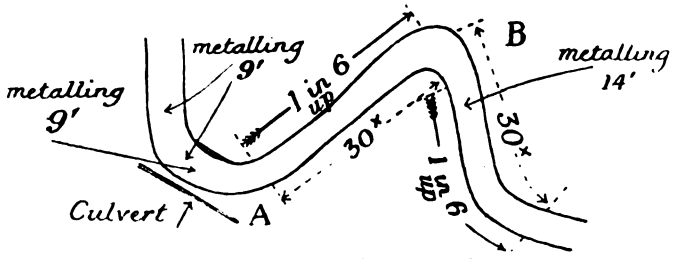
The metalling from Newlands Hotel (B5) to Devil's Elbow (A3) is moderately good, and stone walls are at hand for repair.

DEVIL'S ELBOW (A3).



(6). The above is a hand sketch showing the road at the "Devil's Elbow."

The metalling on culvert is only 9' wide; but it could be widened to 16' at A, and a ramp made so as to enable horses to rush the corner.

At B is a gate where broken-down vehicles could be run in.

If extra horses are required they can be sent back across the fields to south-east of road.

(7). After "Devil's Elbow" the road is fairly level for a mile: metalling moderate.

The road is unfenced, and a stream runs beside it at which horses could be watered without buckets.

The stream bed is full of stones which could be used for metalling.

The last hill up (B2) is 1 in 4½ for 200 yards. There is a level space at top 50 yards × 50 yards where some guns could be run off the road, and their teams sent back by north side of road to help other guns.

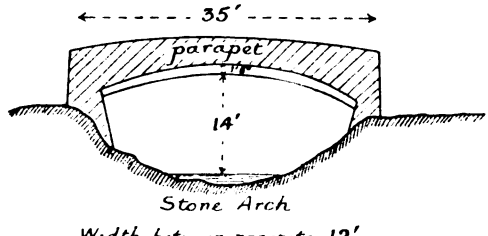
(8). If necessary some guns could be sent down tc Buttermere with four horses to keep road clear; the lead horses being retained to bring up the rest of the guns.

The road from the top to Buttermere is steep (constant gradients of 1 in 6½). There are deep drains across it at intervals which could either be filled in or passed slowly.

There are a lot of side tracks, etc., all along the road, where broken-down vehicles could be run off the road. (See sketch map).

(9). Appended is a sketch of Stair Bridge (A5).

STAIR BRIDGE (A5).
(For other Bridges, see Sketch).



Width between parapets 12'

Stair Bridge is marked as unsafe for heavy vehicles and locomotives, but should be perfectly safe for field guns and howitzers, though not for

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heavy artillery. The latter could not be taken up this pass in any case. Suggested that hedge opposite N.W. end should be cut away for 20 yards, to avoid sharp corner, and facilitate unhooking horses for watering in firm field beyond. Join road again 100 yards along hedge, through the gate.

K. D. YEARSLEY, *2nd Lieut., R.E.*
W. W. PEACHE, *2nd Lieut., R.E.*

DRIFT OF A BULLET.

DEAR SIR,

I have only just seen Major Carey's letter or would have replied to it before. His statement of the two points raised by him is so esoterical as to make it difficult to be sure of what he means.

(*a*). Whether the viscosity of the air is the only factor that can *affect* the *rolling motion of the bullet*. As I do not admit that the bullet rolls I do not see how viscosity, or anything else, could affect a movement which, for me, does not exist. I am satisfied that viscosity could not *cause* the rolling; and I know of nothing else which could.

(*b*). *Why* upward pressure *should be applied* to the nose of the bullet or gyroscope, when every known fact tends to show that the resultant force produces a downward movement of the nose. I do not know *why* the bullet should have its nose pressed upwards when the nose is above the line of the trajectory; but it is a fact. I equally do not know *why* a stone should fall to the earth, but I know it always does. There is nothing inconsistent in the nose of the bullet being pressed upwards whilst the nose is actually moving downwards. Pressing the nose of a rotating bullet upwards will cause *not a vertical* but a *horizontal* movement of the nose.

I am sorry to contradict Major Carey but I think the "rolling theory" of drift, being inconsistent with known laws of Nature, can hardly have any pretensions to being called scientific.

Yours faithfully,

6th November, 1911. R. DE VILLAMIL.

NOTES ON SKI.

SIR,

Now that the ski-ing season is again within measurable distance, the following minor emendations and comments on Capt. Bremner's article on this subject in the *R.E. Journal* for June, 1911, may perhaps be useful.

1. LOCALITIES.—(*a*). *Feldberg* (Black Forest).—Is apt to be very crowded, especially by Germans. Not unlike Norway.

(*b*). *Switzerland.*—The heights—by which most places are judged—are not quite accurately given. Full details are to be found in Baedeker, or Wroughton's *Winter Sports Annual*; some of the more important are:—Davos, 5,100′; Arosa, 5,800′; St. Moritz, 6,000′; Engelberg, 3,300′; Grindelwald, 3,400′; Mürren, 5,400′; Adelboden, 4,500′; Kandersteg, 3,900′; Gstaad, 3,500′; Saanenmöser, 4,200′; Montana, 4,900′; Villars, 4,100′.

The Siegfried Atlas maps, $\frac{1}{50000}$, are admirable, and every ski-runner should use them.

(*c*). *Tyrol.*—St. Anton and St. Christoph are practically synonymous from the ski-ing point of view. In general the country hereabouts is

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steeper than in Switzerland. Heights in Tyrol are lower than in the Alps; hotels and inns 2,500′ to 4,000′, huts perhaps 6,000′. See Baedeker's *Eastern Alps* or Wroughton's book above mentioned.

2. EQUIPMENT.—(*a*). *Telemark Ski.*—Length, for runners of moderate skill, should be to the *tips* of the fingers when the hand is held up above the head to its full extent. The tendency is to have ski too short. Upper surface of ski is better oiled than varnished; snow sticks less to it.

(*b*). *Sticks.*—The tendency among the best runners is to use one light bamboo stick the height of the elbow. The stick should only be used uphill or on the level, like a walking-stick; no decent runner ever uses his stick *at all* downhill (a narrow icy path, where there is no possibility of braking with the ski, is an exception).

(*c*). *Sealskin.*—The detachable kind, preferably with patent clips instead of strap and buckle, is practically universal, and is worth a dozen of any rope arrangement.

(*d*). *Wax* applied hot usually overdoes the effect required.

(*e*). *Repairing Outfit.*—A "tin toe" is just better than nothing. The best provision against a broken point is a pair of small metal clamps (sold in the shops) to screw on.

The so-called "handy tool" is usually dispensed with.

Screws, nails, sheet brass, etc., are most unpleasant to work with on a mountain-side, and are only necessary on a long and serious tour.

(*f*). *Gloves.*—For all ordinary work Jaeger's woollen ski-ing gloves are first-rate. Three pairs should be taken.

(*g*). *Clothing.*—Trousers, tied in round the top of the boot with a bit of old puttee 4′ long, are more comfortable than knickerbockers. The coat and trousers should above all be *thin*, summer-weight stuff. A Viennese oil-silk wind-jacket is a very sound thing to carry in the rucksack.

(*h*). *Goggles* are absolutely essential, even though they may never be used.

(*k*). *Crampons* are advisable.

3. BOOKS, ETC.—Mr. Caulfeild's *How to Ski* is far and away the best in any language for a beginner. Mr. Richardson's *The Ski-Runner* is the next best. The military uses of ski have been dealt with in the *United Service Magazine* and in the *Journal of the U.S.I. of India*. The various clubs all publish interesting literature.

4. CLUBS.—(*a*). *Ski Club of Great Britain.*—At present the premier British club. Covers all branches of ski-running. Requires a moderate standard of skill in its candidates. Subscription £1 1s. 0d. *per annum*. Secretary's address, Caxton House, Westminster.

(*b*). *Alpine Ski Club.*—Ski-running in its application to winter mountaineering, of which some experience is required. Subscription 10s. 6d. *per annum*. Secretary's address, 12, Liverpool and London Chambers, Liverpool.

(*c*). *Scottish Ski Club.*—Address Dr. Wigner, Dundee University. I do not know what the subscription is, but the club is the fountain head of ski-running in Scotland, and is a flourishing and enthusiastic institution.

Yours faithfully,

C. HORDERN.

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BOOKS RECEIVED.

1803. CHANCELLORSVILLE AND GETTYSBURG. By Colonel P. H. Dalbiac. The "Special Campaign Series," No. 13. Price 5s. net. Messrs. Geo. Allen & Co., Ltd., 44 & 45, Rathbone Place, London.

THE CAMPAIGN IN VIRGINIA AND MARYLAND, June 26th to September 20th, 1862. Cedar Run, Manassas and Sharpsburg. By 2nd Lieut. E. W. Sheppard. The "Special Campaign Series," No. 14. Price 5s. net. Messrs. Geo. Allen & Co., Ltd., 44 & 45, Rathbone Place, London.

MY EXPERIENCES OF NAN SHAN AND PORT ARTHUR WITH THE EAST SIBERIAN RIFLES. By Lieut.-General N. A. Tretyakov. English translation. Price 12s. 6d. Hugh Rees, 119, Pall Mall, S.W.

THE IRRIGATION OF MESOPOTAMIA. With Portfolio of Plans. By Sir W. Willcocks, K.C.M.G., F.R.G.S. Price 20s. net. Messrs. E. & F. Spon, 57, Haymarket, S.W.

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A MILITARY WORD AND PHRASE BOOK. German, with English translation. By Professor F. Sefton Delmer, Lehrer an der Kriegsakademie und an der Militär-technischen Akademie, Berlin. Price 3 marks 60 pfen. A. Bath, Mohrenstrasse 19, Berlin.

MANUAL FOR CADETS OF THE O.T.C. JUNIOR DIVISION. Compiled by Capt. G. T. Hankin, O.C. King's Coll. School Contingent, Wimbledon. Price 1s. Harrison & Sons, St. Martin's Lane, W.C.

DERRIÈRE LA FAÇADE ALLEMANDE. Par P.D. du journal "La Dépêche." 1 fr. 50 c. R. Chapelot & Cie., 30, Rue Dauphine, Paris.

MILITARY HISTORY FOR EXAMINATION QUESTIONS ON THE RUSSO-JAPANESE WAR, 1904, from 23rd August to end of October. With Map. By Lieut.-Colonel H. M. E. Brunker. Price 1s. Forster, Groom & Co., 15, Charing Cross, S.W.

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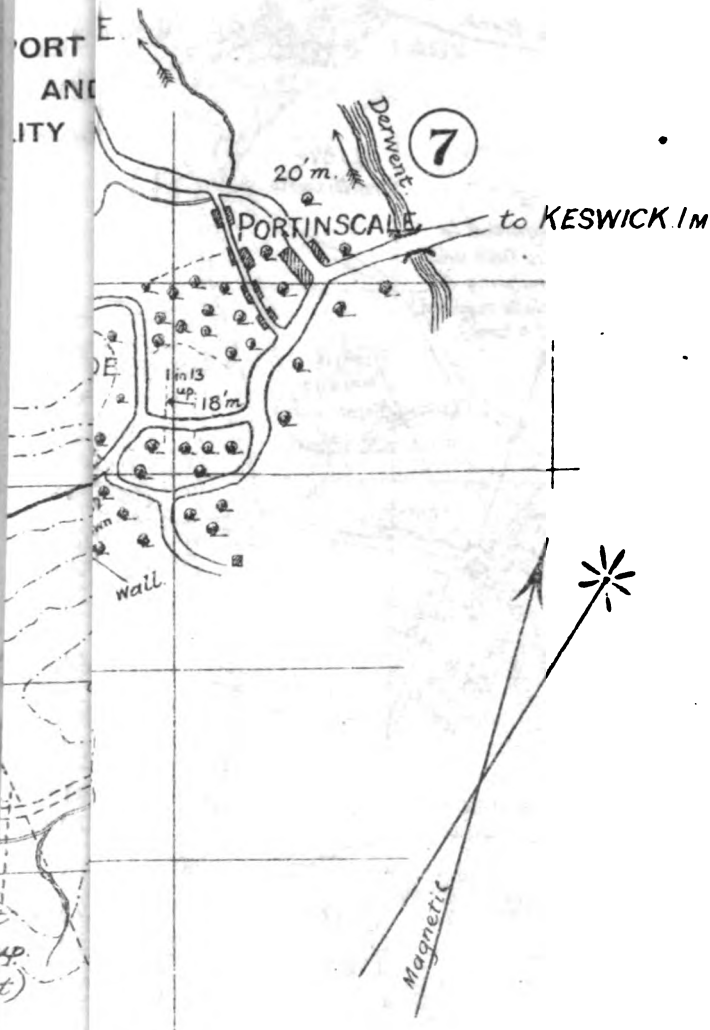

position for M.I. to cover retirement
SIDE has been evacuated
from enemy on CASTLE HEAD.
fective rifle fire on enemy attempting to cross
TODGE, & on most of E. end of pass.
of retreat shewn

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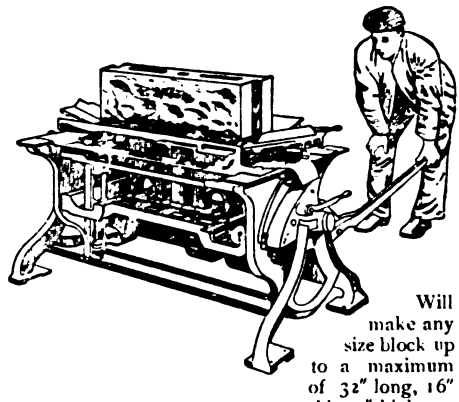

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